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The EDITOR,
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The Month.

Coal Conservation.—We are all agreed upon the paramount desirability of husbanding the national supply of coal, which, under existing circumstances, is an asset of tremendous value to the United Kingdom, furnishing the motive power for the great industrial system upon which the wealth of the country so largely depends, and constituting the main source of light and heat for the entire population. For how long we shall enjoy a cheap and abundant supply of coal, no one can predict with certainty, as it is impossible to say what may be the future rate of increase in consumption, tending to bring nearer the date of exhaustion, or to predict the extent to which it may be found practicable to work deposits below the limit of practicable depth fixed by the Royal Commission on Coal Supplies. Of one thing everybody is thoroughly convinced—that coal will last his time. For this reason, appeals made on behalf of posterity are apt to fall rather flat. The present generation will never accept reforms if the only benefit promised is to be inherited by a future age. Coal owners, coal merchants, and coal miners who live by the export of coal will not be persuaded to give up their earnings for nothing; manufacturers will not be persuaded to abandon wasteful methods of power production unless they can be convinced that other methods can be adopted with results that will be economical to themselves, and householders will not give up cheerful coal fires until an equally pleasant substitute has been provided. These are the difficulties which have to be faced by all reformers, among whom we may rank Mr. Arthur J. Martin, M.Inst.C.E., the author of a paper read at a meeting of the Society of Arts. Mr. Martin does not content himself with stating the desirability of reforms, although this point occupies a considerable portion of his paper. He points out the facts that in power production much could be done by the substitution of economical for inefficient steam engines, and by replacing steam engines by gas engines; that in the various processes wherein coal is used for heating purposes, large economies might be effected by turning the coal into gas, and by passing the products of combustion through regenerators in which to intercept the escaping heat and to transfer it to the air for feeding the fire; and that domestic fires might be replaced with advantage by gas stoves, heat-briquettes and coke. We all know that such measures would save coal, and that all of them are being adopted in increasing measure year by year, not for sentimental reasons, but simply because they often prove to possess pecuniary or other advantages. The chief question is to find out the way by which the benefits of such reforms may be

brought home to the million. Mr. Martin believes this result may be attained by the plentiful supply of coal gas at a low price, and in his paper a scheme is propounded for the generation of gas at the pit's mouth, and its transmission under high pressure to the metropolis. The suggested cost of 1*s.* per 1,000 cubic feet, which is that fixed years ago by Sir William Siemens as the price at which gas would be able to supersede coal for domestic purposes, could probably be reduced very considerably, but the difficulties attending transmission and distribution are by no means inconsiderable. It is the fact that producer gas is being distributed by the South Staffordshire Mond Gas Company over a large district—about 163 square miles—at a rate of from 2*d.* to 4*d.* per 1,000 cubic feet. But this gas has a calorific value which is only about one-fourth that of coal gas; and being of somewhat different chemical composition, does not present the same difficulties in transmission. Again, in the United States, natural gas is conveyed under pressures to 300 lb. per square inch for distances ranging up to 200 miles. But even under the pressure of 300 lb. per square inch, trouble has been experienced in the way of leakage, and double pipes have been found necessary for the purpose of collecting gas escaping from the inner tube and pumping it back into the mains. It is not impossible, of course, to transmit coal gas in the manner proposed, but the point is whether it can be conveyed economically. The leakage of natural gas is no small item, and when it is remembered that the main proportion of this is marsh gas, which has a density of about eight times that of hydrogen, a substance forming 40 per cent. of coal gas, it is clear that leakage must present a serious problem. Moreover, if coal gas were compressed to the pressure of nearly 500 lb. per square inch, proposed by the author, a very large proportion of the volatile and other constituents valuable for heating and lighting would become liquefied, and difficulties of chemical nature would arise, making the transmission scheme difficult of realisation. Let us assume, however, that satisfactory solutions had been found for the engineering and chemical problems connected with the long-distance transmission of gas. We should then want to know who would undertake the stupendous task of manufacturing enough gaseous fuel to supply the entire population of London, who would equip the gigantic works at the coal fields for generating and pumping the gas, who would build the enormous gas holders necessary for containing an adequate reserve storage, and who would lay the gigantic mains for conveying the gas. The cost of the project including generating and compressing plant, and the main transmission line, is estimated at about twenty-five millions, and if we add items not considered by Mr. Martin, such as storage accommodation, distribution pipes, and house connections and the provision of apparatus for burning gas instead of coal, the total cost might be anything between fifty and one hundred millions.

The task foreshadowed by Mr. Martin could only be accomplished by the State, who, we may safely say, will never undertake anything of the sort. Of course, the London County Council might like to make the experiment, but there is not a remote probability that Parliament would allow them to do so. Moreover, it is by no means certain whether the entire population of London would be willing to give up the use of coal and to use nothing but gas for the provision of heat and light. We rather fancy nothing short of an Act of Parliament would persuade them to do so.

Although, taken as it stands, Mr. Martin's scheme is quite beyond the range of practical politics, his paper is distinctly worth reading, and may have the effect of stimulating enterprise in the direction indicated, on a less ambitious but more practicable scale.

Tramway *v.* Motor Omnibus.—A very important discussion on the relative advantages and disadvantages of the electric tramway and the motor omnibus followed the reading of a paper on this subject by Mr. E. Manville, at the Automobile Club last month. There can be no doubt as to the low cost of operating electric tramways, apart from charges connected with interest on permanent way expenditure and sinking fund. If initial capital expenditure be kept within proper limits it is probable that tramways will maintain their present superiority for some time to come. Still, events move so rapidly, that we think municipalities would be well advised not to launch out too extensively in the direction of tramway enterprise. As for existing tramway systems, nothing could be more absurd than the suggestion that they should be abandoned in favour of motor omnibus services, for such vehicles cost more to run than tramcars, and provision for interest and sinking fund would still have to be made in respect of money already sunk. Thus, a change of the kind would involve a heavy increase of existing annual expenditure. The foregoing considerations are sufficient to indicate that the tramway

must be looked upon as a permanent institution, at all events, so far as existing installations are concerned. Apart from the question of economical working, electric tramways offer a means of transport insuring much comfort, excellent lighting, comparatively little noise and vibration, safety, and reliability; and they conduce to improvement of road surfaces along the line of route. On the other hand, tramway vehicles are very liable to delays owing to their inability to pass obstructions on the track, the rails are more or less objectionable to the general public, passengers have to pass to and fro from the middle of the road for the purpose of entering and leaving the cars, and much obstruction is caused in narrow thoroughfares, to say nothing of the wholesale obstruction arising where tramway termini are established in the streets of large cities. Turning to motor omnibus services, we find at once several obvious recommendations. The vehicles are free to pass other vehicles, instead of having to wait until the sleepy or obstinate drivers of horse-drawn wagons choose to get out of the way; they can be drawn up alongside the footwalk for the convenience of timid and non-agile passengers, and intending passengers; the services can be transferred from one street to another, or from one district to another; and the absence of rails is a great advantage to the owners of the vehicles as well as to the general public. But as at present constructed, the motor omnibus carries grave disadvantages. The cost of operation is undoubtedly high, although the balance now in favour of electric tramways will probably be largely reduced before long; the danger of fire is ever present, as frequent reports in the daily Press sufficiently demonstrate; side-slip is another disadvantage remaining to be obviated; and vibration and noise are characteristics which passengers, users of the streets, and householders by no means regard with enthusiasm. Moreover, the fumes emitted by the motors militate against the popularity of motor omnibuses in the opinion of the public. It would be unfair to judge the motor omnibus by the vehicles at present upon the streets. Great improvements may be introduced, removing the more serious drawbacks, and in that event there should be a great future for the motor omnibus, not as a rival, perhaps, but certainly as an auxiliary to the electric tramway.

Portable Electric Tools.—In a paper read before the Glasgow Technical College Scientific Society, Mr. Andrew Stewart has placed on record some facts concerning the design, construction, and industrial application of portable electric tools, for which so great a demand has risen within recent years. Unfortunately, a good many appliances of this description now on the market are of German manufacture—a circumstance that may be considered unfortunate for the two reasons that the importation of foreign-made goods is undesirable in the interests of home industries, and that some of the tools imported are of distinctly indifferent construction from a mechanical point of view and defective in respect of electrical design. It is by no means an easy thing to produce electrical tools of the class under consideration, in which the various difficulties presented have been satisfactorily overcome. The most common cause of failure is the insulation, for as the load increases so do the internal losses which, being converted into heat, are apt to cause inconvenience to the user, and present to the designer the problem of reconciling the demand for small dimensions and lightness dictated by convenience on one hand, with the conflicting demand for a large heat radiating surface dictated by the necessity for low temperatures and stability of the insulation material on the other. Mr. Stewart alludes to the ingenious solution of the problem introduced by Mr. Duntley, of the Chicago Pneumatic Tool Co., who has applied a small four-blade fan on the armature spindle of the electric tools made by his firm, and has found that by this means sufficient air can be blown through the armature to keep that part of the mechanism reasonably cool. It is said that an electric drill with an unventilated motor which had to be stopped after running for ninety minutes on varying load was able to be run, after having been fitted with one of these fans, for four hours without developing a temperature rise of more than 110 degrees Fahr. at the hottest part. In itself, air-cooling is no new thing, but its application in this particular direction is none the less worthy of note. One of the most interesting electric tools described by Mr. Stewart is the magnetic drill post, which can be fixed in any desired position by a magnet in the base of the pillar instead of by the usual bolts and nuts. To fix the post merely involves the turning of a switch, and, as the magnet windings are inside the pillar, there is not much risk that the possible unpopularity of so valuable a labour-saver among workmen will lead to "accidental" injuries of the kind to which such appliances are liable. Having discussed some of the points

entering into the design of electric tools, the author gives a series of results obtained with portable electric drills working on steel and cast iron with ordinary tool steel, the average results quoted being in some cases superior to those obtainable with the best types of machine tool. A striking comparison is given in one diagram between small and large portable drills and radial drilling machines, all operated by electricity. The motor losses in the radial drills are relatively small because some limitations imposed on the designer of the portable tools were absent in the case of the drilling machine, but the mechanical losses in the latter more than overbalance the saving, and the portable drill shows a considerable advantage in each case. Other very handy forms of apparatus mentioned by the author are electrically-driven grinders, and milling machines—appliances which in common with portable drills, are distinctly calculated to aid the modern tendency to take the tool to the work instead of taking the work to the tool.

Electric Motors for Machine Driving.—One result of the popularity gained by electric motors for driving machinery of all kinds is that manufacturers and consulting engineers who are not perfectly at home with electrical practice are very apt to think that the selection of a motor for any given purpose can be satisfactorily made by the aid of a catalogue, and without any serious inquiry into the characteristics of the motor itself. This, of course, is an entire mistake, and those who are contemplating the application of electric driving cannot do better than to read the paper recently contributed on the subject by Mr. W. A. Ker in "The Transactions of the Institution of Engineers and Shipbuilders in Scotland." Like many other engineers making a specialty of some particular branch of work, Mr. Ker has had occasion to notice the unsuitability for its intended purposes of the apparatus sometimes demanded by specifications, and in presenting a series of notes on common errors in the use of electric motors he has performed a really useful public service. From the first four diagrams appended to the paper we may draw the following general conclusions:—motors for practically constant speed and constant torque should be shunt wound; motors for practically constant speed and varying torque should also be shunt wound; motors for approximately constant speed and varying torque, but subject to sudden overloads, should be compound wound; motors for varying speed, and torque varying inversely as the speed, should be series wound; motors for varying speed and constant torque should be shunt wound and provided with resistances for the regulation of speed. Motors which are required to give a large torque for brief periods at frequently recurring intervals are usually fitted with fly wheels, or coupled to machines themselves fitted with fly wheels. It is undoubtedly an excellent idea to store up energy in this way ready to be given up at the moment of demand for more power, and so to relieve the motor of abnormal demands, to equalise the drain upon the conducting mains, and to reduce the peaks of the current curves. But the idea can only be adequately realised by the employment of the proper type of motors. For example, a shunt wound motor varies so little in speed under sudden demands that a fly wheel fitted to it has no practical effect, and, as a matter of fact, the motor has to supply nearly all the additional power suddenly called for. Mr. Ker very candidly pleads guilty to having supplied many shunt motors fitted with fly wheels, having, as he says, "found it easier to accept the customer's specification and to supply fly wheels, than to make the customer understand that he is throwing his money away." We believe that this is by no means an unusual experience, and in view of the objections entertained by most consulting engineers to have their specifications overhauled, and of most purchasers to allow time for necessary information to be obtained by motor manufacturers, it seems probable that unsuitable machines will continue to be fitted with fly wheels until the fact becomes more generally known that compound wound and not shunt wound motors should be employed under such conditions of work. Towards the end of his paper, the author gives a useful list of machines used in engineering workshops, and indicates the proper description of motor to be employed for driving each type of machine. Although this paper conveys no information that is not already possessed by electrical engineers, and mechanical engineers who have sound knowledge of electrical machinery, we feel certain that it will be found helpful to many others who are not equally qualified to select electric motors for their own use, or for the use of their clients.

The Electric Production of Nitrates from the Atmosphere.

It was only in 1898 that Sir William Crookes uttered his note of warning about the possible failure of the wheat supply, and of the fertilizers by which the yield of the wheat-fields of the world might be increased, and named the remedy; and to-day we have a practical working factory taking nitrogen from the atmosphere, and producing nitrates that are stated to be quite equal in fertilizing value to the best natural deposits, and able to compete with them in cost. It is also interesting to note that it was only when Sir William brought the matter before the public, by the aid of the British Association,* that the matter was really taken up in a practical spirit. Wheat obtains its nitrogen from bacteria which grow in the soil, and which are fed by certain plants which also grow where wheat grows. But the amount of nitrogen available per crop, through the agency of the bacteria and the plants named, is limited, and the wheat yield per acre, if dependent on them, would be small. Hence the necessity for nitrogenous fertilizers. The chief of these is nitrate of soda, exported from the nitre beds of Chile. As was pointed out in the last issue of THE ENGINEERING REVIEW, the demand for this has risen from 1,000,000 tons in 1892 to 1,543,120 in 1905, and that supply will be exhausted within 50 years. Hence the necessity for finding an artificial method for the production of nitrates.

In 1781 Cavendish showed that nitrogen could be made to combine with oxygen, if electric sparks were passed through. In his researches on the composition of atmospheric air Lord Rayleigh caused an arc to be formed, between platinum poles, in an atmosphere rich in oxygen. The nitrogen first combined with the oxygen, forming

* Cf. ENGINEERING REVIEW, p. 212.

THE NITRATE FACTORY AT NOTODDEN.

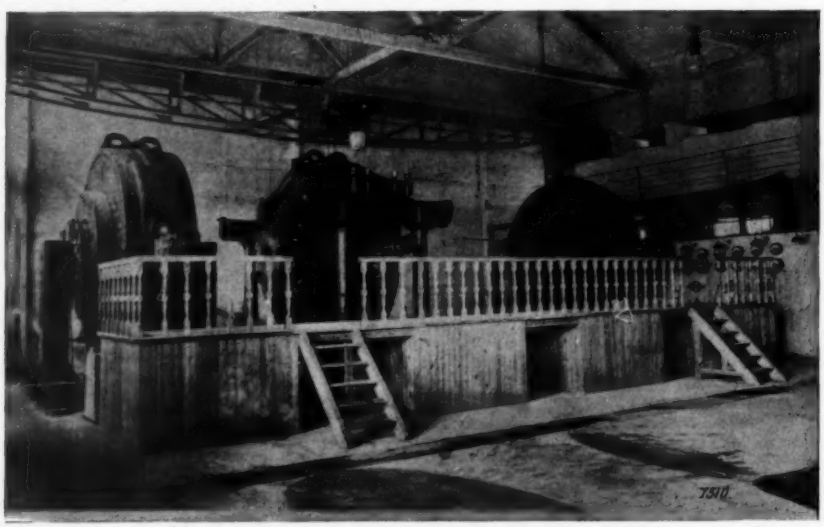
THE ARC

nitric oxide, NO, and the nitric oxide then took up another atom of oxygen from the excess present, forming nitrogen peroxide, NO_2. The nitrogen peroxide was absorbed as fast as it was formed by a jet of caustic soda playing in the flask in which the arc was burning, the result being a mixture of nitrate and nitrite of sodium. It appears to be a disputed point whether the nitrite is of any manurial value, but the nitrate is the well-known Chilian saltpetre referred to above.

No process for the synthesis of nitrates from the air has been found commercially practicable until recently.

The Birkeland and Eyde system, which has achieved practical commercial success, and has been worked out in Norway, was briefly described in the March number of THE ENGINEERING REVIEW;* but we are now enabled to give some views of the factory as well as some additional information. Alternating current at a pressure of 5,000 volts is employed to form an arc, between a single pair of copper tubes fixed between the poles of a powerful electro-magnet. The ends of the tubes are $\frac{1}{8}$ in. apart, and the electrodes are kept cool by a stream of water running through them. The flame produced from the arc is maintained

* Page 212.



THE FURNACE ROOM, SHOWING THE THREE 500 KILOWATT FURNACES.

ABSORPTION APPARATUS AT NOTODDEN.

practically continuous, but in a very peculiar form. When the arc is struck first, it is formed between the ends of the electrodes, but the magnetic field set up between the poles of the electro-magnets drives it away from the electrodes, until it breaks and it assumes the form of a large disc of flame, in some cases as much as 3 ft. in diameter. The succession of arcs occurs about 1,000 times per second. Air is forced into the space between the electrodes, and passes out at the periphery of the flame disc, the whole apparatus being enclosed inside an iron drum lined with asbestos and mica. The temperature at the hottest part of the flame is 3,000° C., and it is there that the first oxidation takes place, resulting in the formation of nitric oxide. The nitric oxide passes out of the furnace mixed with air, and at a temperature of 700° C, and is cooled by causing it to pass through a nest of boiler tubes, steam being raised in the boiler for use in a later part of the process. The nitric oxide leaves the boiler at a temperature of about 50° C, and immediately takes up a second atom of oxygen from the air with which it is mixed, nitrogen peroxide (NO_2) being formed. The NO_2 and the air with which it is still mixed, are passed through four successive water towers, arranged on the lines of gas scrubbers, water trickling down inside them over granite slabs and lumps of quartz, the gas passing upwards and forming nitric acid. The liquid that has done its work in the last tower is used for the absorbent in the third tower, that of the third in the second, and so on, the quantity of nitric acid becoming greater and greater, till at the first tower, from which it is drawn off, the liquid contains 50 per cent. The bulk of the solution of nitric acid is treated with lime stone, a supply of which is obtained in Norway and Sweden, nitrate of lime being formed. A small portion of the nitric acid is employed in converting the nitrite as will be explained. The gas which has

passed through the four water towers, and which still contains some nitrogen peroxide, is passed through a fifth tower, where it is treated with a solution of milk of lime, and finally it passes over beds of quicklime. From the last two processes, which it will be understood are to extract the last portions of the nitrogen peroxide, a mixture of nitrate and nitrite of calcium are produced, and as the manurial value of the latter is doubtful, the mixture is subjected to a further treatment. A small portion of the nitric acid obtained from the first water tower is added to the solution, and the whole is evaporated by the aid of the steam generated in the boiler, heated by the hot gases coming from the furnace. The nitrite is decomposed, nitrous fumes pass over and are absorbed by a solution of lime, the result being the formation of a solution of nitrate of lime. The whole of the nitrate is concentrated by evaporation. It is put on the market in different forms: in the fused state, in which form it contains 13·5 per cent. of nitrogen; in crystals, containing four molecules of water of crystallisation; and as a dry powder, which is not deliquescent. In the fused state it is poured into iron holders, for shipment.

Messrs. Birkeland and Eyde have two distinct establishments, one for research and the other for production. The research factory—for it is a small factory—is situated at Vasmoen near Arendal. It contains furnaces employing from 250 to 300 kw., so that the researches are on a thoroughly practical scale.

The producing factory is situated at Notodden, where it has the double advantage of cheap water carriage for its products, and for the raw material—limestone—that it employs, and of cheap power for its current. At present power is taken from some turbines that were laid down a few years since for driving a pulp factory. The power is obtained from the River Tinnelf, at one of its falls, where the turbines generate about 6,000 h.p., and the pulp factors let off sufficient for the three 500 kilowatt furnaces at present in use at Notodden, at the extremely low price, it is stated, of £1 14*s.* 4*d.* per kilowatt year, or, taking a full 365 days, and 24 hours per day, at a cost of 0·047*d.* per kilowatt hour. The yield is stated to be 500 kilogrammes of the anhydrous nitric acid per kilowatt year, which would make the cost for power about £3 8*s.* 8*d.* per ton. There is a sufficiently wide margin between this figure and the cost of Chilian nitrate delivered, to allow for labour, which is always small in processes of this kind, once they are established, and for packing, freight, &c., so that apparently there should be a good field for the product.

High-Speed Driving-Wheel Tyre Turning.

THE accompanying illustrations and diagrams show the high-power high-speed lathe, roughing, tapering and finishing tools employed in a recent test, using high-speed tool-steel, in turning ten pairs of locomotive driving-wheel tyres in a trifle over nine hours. The tyre was finished in twenty-four revolutions, this being done on an average of twenty-two revolutions actual cutting. As noted by the two diagrams, sixteen revolutions were required with the roughing tool and eight revolutions with forming tools.

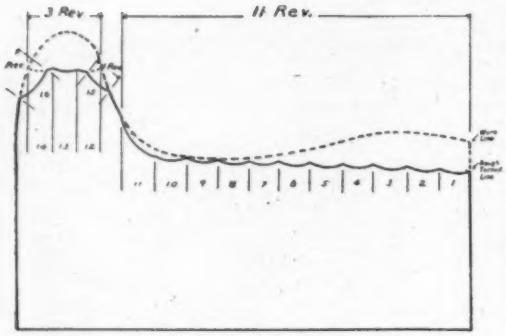
This remarkable record was undertaken at the New York Central Shops, at Albany, New York, recently, on a "Niles" 90-in. driving-wheel chucking lathe. The accompanying table shows most interesting data of the cutting speed in feet per minute, on tyres 64 in. and 79 in. diameter, the feed per revolution being $\frac{15}{32}$ in. and the size of the tool 3 in. by $1\frac{1}{2}$ in. The time of cutting, it will be noted, varies from forty-three to fifty-two minutes, while the time required for changing wheels varied from eight to ten minutes, the depth of cut ranging from $\frac{3}{8}$ in. to $\frac{9}{16}$ in. The average time required per pair of tyres was 54·6 minutes, and this gives a most excellent idea of the great advances made with the use of high-power tools and high-speed tool-steel.

As a result of this test at the Albany shops, the following suggestions have been given as to best methods for handling a lathe for high-speed turning of locomotive driving-wheel tyres. The left hand crank pin is placed in the pocket in the face plate in putting the wheels in the lathe, and the movable head is run up by the electric motor until the grip pieces of the drivers are close to the tyre.

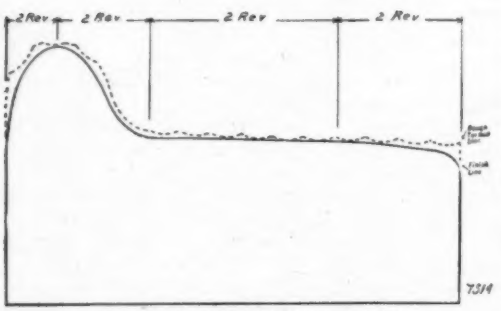
The head is clamped and the wedges are driven up with a light hammer, forcing the grip pieces into the tyre. The clamp bolts are put on and tightened with a 3 ft. wrench, and after starting the cut, if there is dirt on the tyre, the wedges are driven a little further. A cut is made in to the lowest spot after selecting the smallest wheel in the set, the slide rest is marked, the tool withdrawn, and the rest moved to the outside of the tyre, the tool being run in to the mark on the slide rest. The cut is started and calipered, using $\frac{5}{16}$ to $\frac{7}{16}$ in.

DATA OF TEST IN TYRE-TURNING MADE AT NEW YORK CENTRAL ALBANY SHOPS.

Diameter of Tyre.	Cutting Speed.	Feed per Revolution.	Depth of Cut.	Size of Tool.	Time Cutting.	Time Changing Wheels.	Total Time.
Inches.	Feet per Minute.	Inches.	Inches.	Inches.	Minutes.	Minutes.	Minutes.
64	12⅝	15/32	7/16	3 × 1½	45	8	53
64	12¼	15/32	7/16	3 × 1½	46	9	55
64	12½	15/32	9/16	3 × 1½	44	10	54
64	13⅜	15/32	½	3 × 1½	43	9	52
64	12½	15/32	9/16	3 × 1½	42	8	50
64	10⅝	15/32	½	3 × 1½	50	8	58
64	8½	15/32	5/16	3 × 1½	52	8	60
64	11	15/32	½	3 × 1½	47	9	56
79	14	15/32	½	3 × 1½	46	10	56
79	14	15/32	7/16	3 × 1½	43	9	52
					458	88	546



SIXTEEN REVOLUTIONS WITH ROUGHING TOOL.



EIGHT REVOLUTIONS WITH FORMING TOOLS.

feed. The run is made across the tread at as high a speed as the tool will stand, and according to the hardness of the tyre. It is maintained that from ten to fifteen feet per minute is the usual speed, the tread being roughed out in eleven revolutions, as noted in the accompanying diagram.

The tool is then withdrawn to the height of the flange about $\frac{1}{8}$ in., with a 4-pitch cross feed screw, this taking four and a half turns of the cross feed handle. After feeding across the top of the flange about three revolutions, with the same tool, the back of the flange is roughed down as well as the front of the flange, in one revolution for each, this all being accomplished with one setting of the tool.

The scraper is next applied to the tread of the wheel, this being smoothed up in two revolutions, and often in one revolution if correct size is obtained by the roughing cut. The flange is then finished by means of the forming tools, about two revolutions being required for each side. The chamfering and bevelling tool is then applied to the outside of the tread, this taking about two revolutions, and the wheels are then completed, and ready to be replaced by the next pair.

It is said that the clamp bolts, with practice, can be loosened without the slightest difficulty during the last revolution of the lathe, and the binder bolts of the movable head are then loosened, the head being run back by the electric motor, and the wheel supported by the crane. It is held that the actual turning time should be less than an hour, with a good quality of steel, and modern equipment of lathe and electric power.

1. TURNING A PAIR OF DRIVERS IN AN HOUR.
2. TOOL FOR FINISHING OUTSIDE OF FLANGE IN TWO REVOLUTIONS.
3. TOOL FOR TAPERING AND FINISHING OUTSIDE EDGE OF TYRE IN TWO REVOLUTIONS.
4. TOOL FOR TAPERING AND FINISHING OUTSIDE EDGE OF TYRE IN TWO REVOLUTIONS.
5. FINISHING TOOL IN TYRE TURNING.
6. ROUGHING TOOL.

Recent Examples of Concrete-Steel Construction—II.

By W. NOBLE TWELVETREES, M.I.Mech.E.

Water Tower or Reservoir at Newton-le-Willows.

AMONG the varied applications of reinforced concrete, there is none in which the material is more usefully employed than the construction of storage reservoirs of different types suitable for the requirements of small districts and of industrial establishments.

Fig. 8 is a sectional elevation of the water tower or reservoir recently constructed at Newton-le-Willows, Lancashire. The tower forms part of a scheme prepared for the Urban District Council by Messrs. Read and Waring, of Westminster, and receives water from the adjacent pumping station drawing supplies from a deep well. When preparing the details of the general project, the engineers had before them two alternatives—the construction of an ordinary service reservoir on elevated land at a distance of some two miles, or the erection of an elevated reservoir close to the source of supply.

The second alternative presented very evident advantages, the cost of constructing a reinforced concrete reservoir was found to be less than for a covered reservoir of the ordinary type, plus the cost of a pumping main; in the second place, by building the reservoir close to the pumping station there would be a considerable saving in the first cost and upkeep of service mains, a proportionate reduction in the power of the pumping engines, and, by avoiding the necessity for two separate stations, an important reduction in establishment charges.

Of course, the elevated reservoir might have been built of cast-iron or steel and

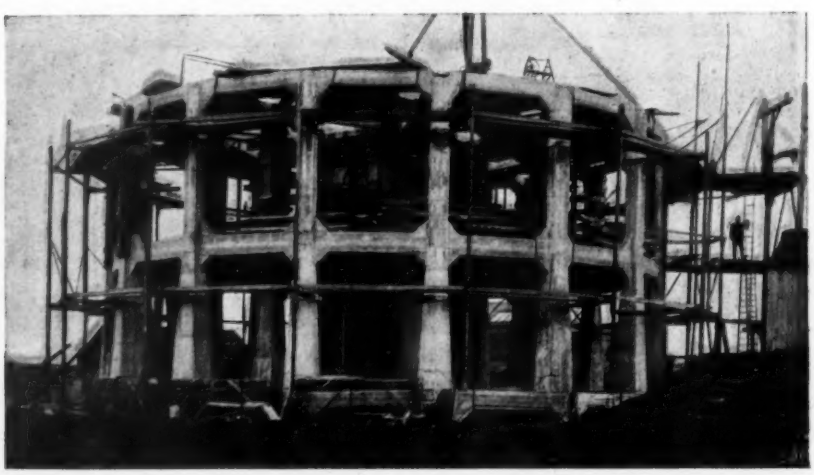


FIG. 7.—VIEW OF THE RESERVOIR UNDER CONSTRUCTION.

erected upon a brick tower; but apart from the well-known objections to metal tanks of large size, the cost would have been far above that of reinforced concrete, a material that lends itself to economical construction, and, being unaffected by the corrosive action of air and water, is particularly suitable for the storage of water.

Fig. 8 shows that the complete structure includes a circular reservoir with an internal diameter of 72 ft. and a water depth of 12 ft., giving a capacity of 300,000 gallons. This reservoir is supported on twenty-eight columns. The four minor columns form the corners of a square shaft or tower which accommodates the inlet and outlet pipes, and contains a cast-iron circular staircase for access to the valve chamber and top of the tank. The remaining columns form two rings, and are connected by radial and circumferential beams of monolithic concrete-steel construction.

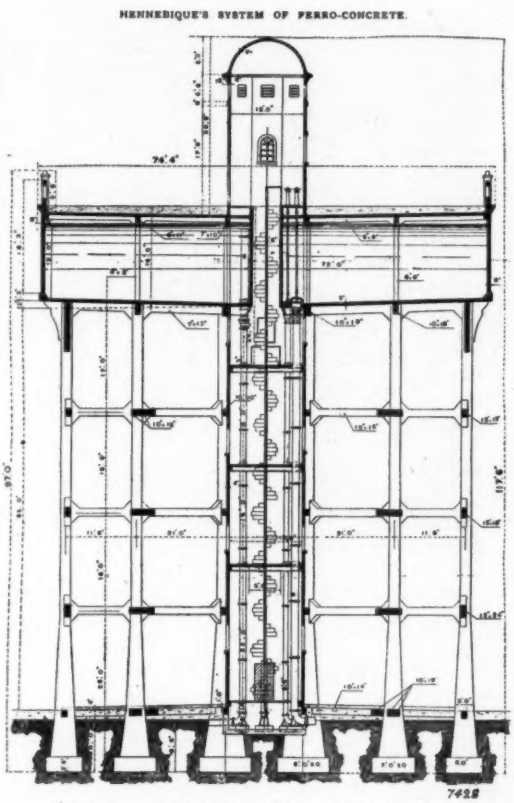


FIG. 8.—SECTIONAL ELEVATION OF THE RESERVOIR.

The reservoir proper is built with walls of concrete 6 in. thick, reinforced by steel rods suitably placed for resisting the stresses due to outward pressure. The floor is formed by radial beams 7 in. wide by 15 in. deep, and two ring beams 10 in. wide by 19 in. deep supporting a monolithic floor of concrete-steel 6 in. thick, the beams and slab being reinforced in the manner characterising the "Hennebique" system. In addition, the floor is further supported by a ring of arches 10 in. wide connecting the outermost series of columns, and by corbelling with a projection of 2 ft. 6 in., and a depth of 6 ft. 6 in., the corners of the reservoir being thickened to form a plinth of triangular section with a depth of 1 ft. 3 in. The roof consists of a concrete steel slab 4 in. thick supported on pillars and radial beams measuring 5 in. wide by 9 in. deep, an inner ring beam 7 in. wide by 10 in. deep connected with the central, lower, and second ring beam 8 in. wide by 11 in. deep, and a cornice virtually constituting a ring beam projecting 5 in. from the wall and 9 in. from the roof slab. This cornice is carried up above the roof to provide for the bed of sand (intended to protect the reservoir top from the direct rays of the sun), and also forms part of the parapet rising to the height of 5 ft. 6 in. above the surface of the sand. Intermediate support for the roof of the reservoir is afforded by a ring of columns 8 in. square, which are shown in Fig. 8, and also in the photo of the reservoir reproduced in Fig. 9. This view shows two

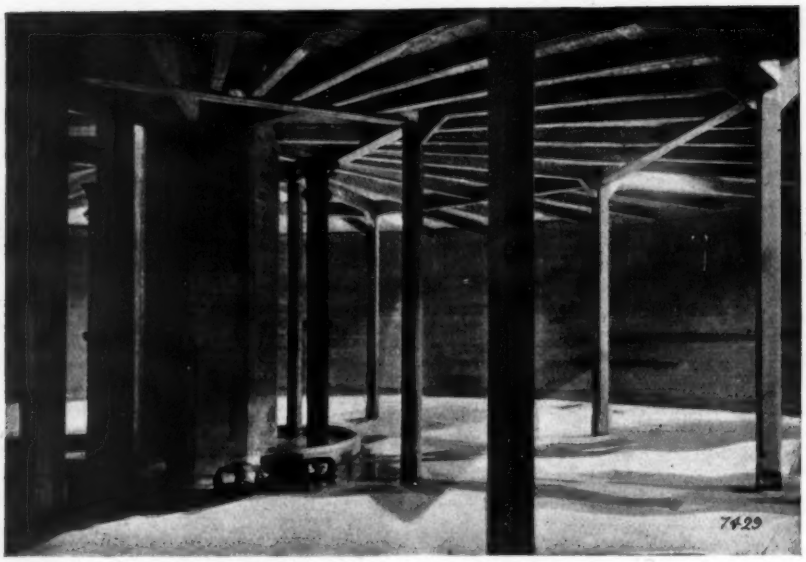


FIG. 9.—VIEW OF THE RESERVOIR SHOWING DELIVERY PIPES AND VALVES

delivery pipes and part of the valves connected at the top of the service pipes.

The foundations of the four columns at the corners of the central tower are 6 ft. square, those of the intermediate columns 7 ft. square, and those of the outer ring 6 ft. square. All these foundations are 2 ft. 6 in. deep, and the bottom surfaces are about 10 ft. below ground level on solid sandstone rock. At ground level the columns are 3 ft. square in cross section and above the first tier of horizontal beams, they have parallel sides and a cross section of 1 ft. 9 in. square, the radial beams between ground level and the under side of the reservoir proper measure 12 in. wide by 15 in. deep, and the ring beams are of different dimensions on the different tiers and in each ring, as indicated in the sectional elevation. Fig. 7 is from a view taken during construction, and gives a good idea of the tower which rises to a total height of 107 ft. above ground-level.

Construction was commenced in July, 1904, and completed in October, 1905, when the tank was filled with water, the contractors being Messrs. W. Cubitt & Co., of London. This is by far the largest reservoir of the kind hitherto built in this country, having twenty times the capacity of the similar structure which has been in use for five years at Bournemouth.

The Prevention of Coast Erosion.—IV.

By Dr. J. S. OWENS, B.A., A.M.Inst.C.E., F.R.G.S.

PASSIVE defences, as before pointed out, usually take the form of sea walls, breastworks, or embankments; that is, something of the nature of a barrier erected to place a limit to the ravages of the sea. The nature of the barrier which we set up is largely determined by the question of cost; other considerations, no doubt, come in, but this is very often the main one; and many a wall and embankment have been erected in such an economical manner that they have entirely failed to withstand the attacks of the sea.

There are cases in which, although making an occasional violent attack upon the land, the sea is on the whole receding, and large areas are being snatched from it and reclaimed; in such, economy can be fairly practised, as it has been found by experience that earth embankments usually give sufficient protection. Given reasonable solidity of construction, the most important point to attend to in such cases is usually the height of the embankment; for the danger to be most dreaded is the water getting over the top during high spring tides. When it once flows over in any quantity, the result is nearly always disastrous, since little reliance can be placed upon the resisting qualities of the material itself, and breaches and flooding of the reclaimed land are the inevitable result.

In determining the height to which such an embankment should be carried, calculation cannot be based on the height of ordinary high water mark, as the tide rises several feet above this under special conditions of wind and air pressure, as much as four or six feet sometimes.

When superimposed upon a high tide there are also high waves. It will be seen that to keep the water out, the embankment must be carried to a considerable height above high water of spring tides, depending, amongst other things, upon the exposure of the site, which determines the height of wave to be expected. Where the wall is protecting reclaimed land, and, therefore, has probably a very flat gently sloping foreshore seaward of it, the waves are never likely to be high, and in this case, assuming six feet as a probable maximum height, the crest of the wave will be approximately three feet above the water level, adding this to, say five feet, to allow for extraordinary tides, we get eight feet above high water of spring tides as the height to which the embankment should be carried.

The probability of getting a large variation in the height of high water is, I believe, much greater where the range of tide is great than where it is small; for instance, where there is a range of from forty to sixty feet, as in the Bristol Channel, to have this increased to forty-five or sixty-five by special circumstances, is more likely than to have a tidal range of one or two feet increased to six or seven. It is, therefore, always best, where possible, to obtain on the spot data as to the highest known tide.

The extraordinary nature of such occurrences makes it almost certain that such data will be obtainable, someone will have made a mark to show the highest point reached.

Sea walls admit of considerable latitude in design, the main points to be kept in view being, to make them high enough and strong enough. The question as to shape of face then becomes, what shape will do the least harm.

The design of a wall and the nature of the section is a matter of calculation when the forces which are acting on it are known; for instance, a retaining wall subject to certain pressure from behind, or a dam to hold up a certain head of water; but in the case of sea walls we are at a disadvantage in this respect, since the forces opposed to us are of the most erratic and variable nature.

Thomas Stevenson records a pressure of 7,840 lbs. per sq. ft., as registered by a dynamometer erected at Dunbar for measuring wave force, and an average of 2,086 lbs. for six of the winter months was recorded by his dynamometer at the Skerryvore rocks in the Atlantic.

The blows of storm waves upon a wall tend not only to disintegrate the structure itself, but also to set up movement in the earth at the back, due to vibration; so that even as retaining walls, sea walls cannot be considered as having to merely support a

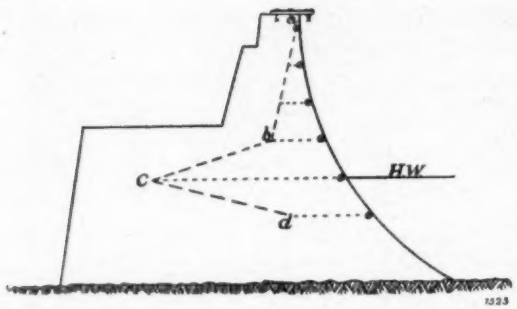


FIG. 1.

dead weight of earth at the back. The disruptive action of the water contained in crevices and cavities of a wall, when struck by a wave, also complicates matters; in fact no reliance can be placed on theoretical calculations for such walls, and experience alone can be relied on.

The conditions to be fulfilled by a wall for foreshore protection are very different from those which must be satisfied by a training wall, breakwater, or pier which has always a good depth of water immediately in front of it, and which is consequently not exposed to the action of breaking waves to the same extent.

It has been found that waves of oscillation, when striking a vertical wall, do not break, but rise against the face to a height which is approximately equal to the height of the wave from trough to crest. The falling back again of the mass of water generates a wave known as the reflected wave, rolling away from the wall; this will occur if the inclination of the wall face to the perpendicular is not greater than forty-five degrees.

In the case of a wall which has shallow water at the toe, and is consequently subject to the blows of breaking waves, the rebound from the wall is one of the most destructive agencies which we have to cope with. To reduce the effect of this rebound, walls of all shapes have been tried, some engineers favouring a hollow curved face up which the waves run and expend their energy without doing serious damage; but the back wash from such a face scours away the sand or shingle lying on the lower part of the curve, and often causes serious erosion in front of the wall. A wall having a stepped face instead of a smooth curve has a considerable advantage in this respect, as the steps break up the back wash and help to check the growth of its velocity, and for this reason it is better to use such a wall when we wish to build up the shore in front of it. Stepped walls are usually built of concrete, the face being of block work and backed up with concrete in the mass. When exposed to great attrition from moving pebbles and stones the blocks may be faced with stone, preferably granite or basalt; the latter being specially useful for such works on account of its high specific gravity and hardness.

The chief objection to such stepped faces, when the steps are of sufficient size to be of any use, is that the amount of material required in their construction is much greater than in the vertical or nearly vertical type of wall; a further objection being that the weight of the material is not utilised as efficiently as it might be, since in stepped walls, the stones or blocks in the face not being vertically over each other, the advantage of the superincumbent weight is thus partly lost.

Thomas Stevenson obtained some very important results from his dynamometer experiments as to the distribution of wave force upon a wall. He fixed a series of his instruments flush with the face of a sea wall at Dunbar in 1859, as shown in Fig. 1. The dynamometers consisted of a flat disc, or plate, pressed forward by a spiral spring, and having an arrangement to register the compression of the spring, when a wave struck the disc. It will be noticed from the figure that he got the greatest pressure at the level of high water, the distribution of horizontal force being shown by the line a. b. c. d. The greatest force registered by these instruments at Dunbar was three and a half tons per square foot.

Simultaneously with these observations he took others with instruments fixed to a piece of wood, bolted to the coping of the parapet, and projecting over the edge with the discs pointing downwards (see Fig. 1), so as to register the vertical force. The maximum vertical force so recorded was upwards of 1 ton (2,352 lbs.) per square foot, whereas the greatest horizontal force recorded by the highest flush dynamometer, which was 18 ins. below the coping, never exceeded 28 lbs. The overhanging dynamometer was 23 ft. above the sea at the time of observation.

It must be remembered, when considering these results, that the horizontal force due to a wave depends upon the direction of impact and the velocity of the water

particles, and consequently upon the shape of the wall which determines the direction of impact.

Hence, when the water is wholly deflected from a horizontal to a vertical direction, it follows that the energy of the deflected water can produce no horizontal pressure against the vertical part of the surface. This vertical force due to deflected water constitutes a serious danger when projections are left for the water to strike against, such as overhanging string courses and copings. The concussion due to waves striking such has been found to cause great damage during storms, and even to necessitate the hewing off of the projections.

Stevenson also showed the great force which the recoil of the waves from a sea wall can exert. At Dunbar he fixed dynamometers to a pile seaward of the wall and having their discs facing the wall, while others were fixed to the same pile facing seawards. He found the force of the recoil to be on one occasion as much as one ton, while the direct force of the waves was only seven cwt. per square foot, the force of recoil being three times the direct force. This instance must be regarded as exceptional, but it shows that the reflected wave is by no means to be ignored.

Turning now to a consideration of the best form for a sea wall, there are some general rules which may be laid down for our guidance in determining this.

These may be stated shortly as follows:—The form of the face should be such that the waves shall not concentrate their striking energy on one part, but have it gradually abstracted from them over a large surface.

The strongest part of the wall should be where the greatest amount of deflection of the water striking it occurs, and where consequently the greatest pressure is exerted by the waves upon the wall.

The water should be so directed by the wall that it will not pass over the top and fall behind it, but rather be reflected somewhat seawards.

The shape of the face should be such that it will either tend to break up the blow of the waves and check the growth of velocity in the back wash, as is the case with walls having a stepped face, if the steps are of sufficient size; or, on the other hand, if it is decided to have a smooth face, it should terminate on the top by inclining a little seaward of the vertical, and on the bottom or toe it should conform to the gradient of the shore, so as to direct the returning water tangential to its surface and so reduce the scouring effect to a minimum.

Angles and projections in plan should be avoided, especially re-entrant angles, as there is a distinct concentration of wave force by such. This was also proved by Thomas Stevenson's dynamometer experiments; he placed an instrument in the angle where a new and old wall joined, and found it registered higher pressures than similar dynamometers placed on the wall elsewhere.

The choice of materials for the construction of sea walls depends greatly upon circumstances. As pointed out above, there are certain cases where the onslaught of the sea is not of such a determined nature as to require a very costly form of construction, and where practically anything in the nature of a wall, if high enough, will be sufficient protection. On the other hand, the forces arrayed against us may be of such a nature that the very heaviest and most durable structure which engineering science can devise, is required to withstand their attack. Between these two extreme cases there is an infinite gradation of others, where the greatest skill is required to so design the structure that it will be strong enough and at the same time not too costly. It should, however, be taken as a rule that no undue risk ought to be taken in coming to a decision. As has been mentioned above, too great economy has often resulted in an entire failure on the part of the wall to fulfil its functions, and for some inscrutable reason, economy, especially in the construction of earth embankments, often takes the form of insufficient height.

Of the materials of construction, the following are those most commonly used:—Timber, fascines or faggots, earth, masonry, concrete, and reinforced concrete. We will now consider these in order:—

Timber Breastworks and Walls are commonly constructed of a row of heavy piles, driven at intervals of 5 or 6 ft., the intervening spaces being closed by sheet piling up to a little above the shore level, and above the sheet piling by horizontal timbers, securely bolted to the main piles; the whole being stayed by tie-rods, raking struts and walings. The sheet piling is in other cases continued to the top of the breastwork, and the horizontal timbers dispensed with. The timber employed in such work is usually pitch pine, oak, or elm for the main piles, and pitch pine or red deal for the remainder. It should in all cases be thoroughly creosoted under pressure for this class of work, as this treatment adds to the life of the structure.

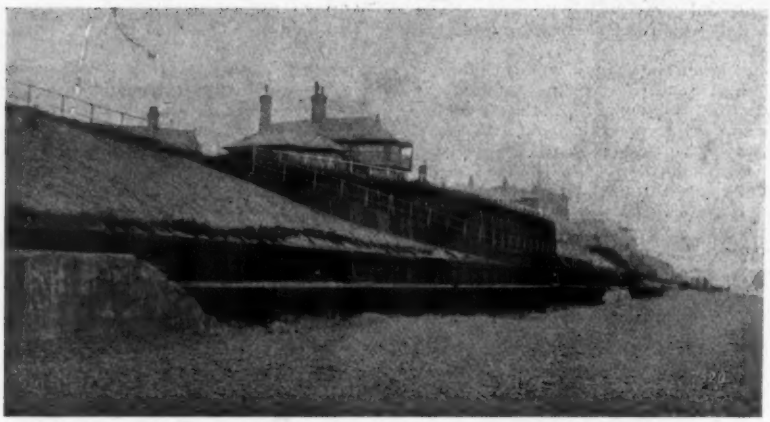


FIG. 2.—TIMBER BREASTWORK AT SOUTHWOLD.

All iron work, bolts, nuts, tie-rods, &c., should be coated while hot with coal tar. If properly done this will form a hard varnish over the surface, adhering firmly and protecting from corrosion; it should be noted, however, that the iron should be well heated before applying the tar, and further that it should not receive a coat of paint or boiled oil first, as this prevents the proper adhesion and drying of the tar. Galvanising is not much protection, as it is found that sea water attacks the zinc and corrodes it away.

Timber embankments are shown in Figs. 2, 8, 9, and 10; in these a step is provided to take the rebound of the waves. Figs. 8, 9, and 10 will be referred to again.

Fascine Embankments.—It can hardly be said that sea walls are constructed of fascines entirely, but when there is already a natural or artificial bank of sand or clay, fascine work can be used successfully for protecting the surface from wave and current action. In Holland, where fascine work is extensively used, embankments are sometimes constructed by sinking a series of mattresses ballasted with earth, stones, and the like, one on top of the other; the upper mattresses gradually diminishing in width, so as to give a slope of three to one on the outer side, which slope diminishes as the structure rises to its full height. Each layer of fascines is held in position by rows of stakes, which stakes are again supported by strong hurdles. Sometimes the lower part of the bank is, in Holland, constructed of fascines and the upper part of masonry or timber.

"The chief materials required in the construction of fascine banks are long reeds, rye, or wheat straw, stakes, twigs, and long branches of flexible aquatic shrubs, especially of willow, poplar, aspen, or any slightly resinous white wood; gravel, pebbles like those used for roads, or broken stone, and a grassy and clayey turf, such as is found in lakes, leading from stagnant waters into the high seas. The principal properties of these materials should be—first, to take root and extend easily in existing ground; secondly, by their flexibility to yield to all the undulations of the foundation; thirdly, from their light weight to remain floating during the early periods of carrying on the works, and of being easily immersed by the aid of gravel and sand; fourthly, to afford by their interstices a multitude of small fissures for the water, and to arrest at the same time, like a kind of filter, the material held in suspension, so as eventually to consolidate the whole."*

In Holland, when a sea bank is being eroded by currents, it is often protected by sinking fascine platforms over the injured part, and staking them in position. The fascine bundles, of which the platforms are constructed, consist of branches of six or eight years growth, tied with all the larger ends in one direction.

* "Two-thirds of the branches should be of full length, and not exceed 3½ ins. in diameter. They should be cut shortly after the fall of the leaf, so that that they may not vegetate after they are fixed in their places."

The fascine bundles are of different lengths according to the custom of the locality. In Holland they are 8 to 9 ft.

* "Great North Holland Canal." By B. W. Jackson, Min. Proc. Inst.C.E., Vol. vi., p. 101.

long and 1 ft. 3 ins. to 1 ft. 8 ins. in circumference. They are bound in the same way as firewood is in England.

When being laid, the small end of one is fixed to the large end of the other bundle. A number so fastened are termed sausages, and may be as long as 20 ft., the bands being 4 ins. to 6 ins. apart.

The fascine platform is sometimes made of seven layers, each being laid at right angles to the one above; the two lowest consist of a grating formed of bundles crossing each other in rows at intervals of 3 ft., and well tied together, the next three layers consist of matting, formed of reeds or straw, and the sixth and seventh layers are of fascine bundles, laid similarly to the two first, and bound together with tarred rope. The total thickness is about 3 ft. A network of willow hurdles is then fixed on the upper surface with stakes; the platform is floated to position and sunk by gravel or turf, one end being fixed to the shore.

The Dutch use a platform called "sinkstucke," which is somewhat heavier than the above, when the work is exposed to sea waves. These "sinkstucke" are generally 36 by 72 ft. by 4 ft. thick.

Fascine work has not a very long life if exposed to the sea, and it requires a great deal of attention to maintain. Straw or reed matting is sometimes used to protect the surface of earth banks, but it has been found that it must be constantly renewed, if exposed to the sea, generally twice a year and often three times, its efficient life being never more than a year.*

Earth Embankments.—The material of which an earth bank is composed largely determines the angle at which the sides will lie. It is found that a small proportion of moisture in the clay increases the cohesion and the frictional resistance to movement between the particles, that is, if the moisture is only in sufficient quantity to make the clay damp. If there is a larger quantity of water, so that it becomes saturated, the angle of repose is reduced considerably, down to ten degrees if very wet. This shows the great importance of providing sufficient drainage in earth embankments.

The angle of repose for well-drained clay is about forty degrees to forty-five degrees, for gravel and shingle thirty-five to forty-eight, and for dry sand twenty-one to thirty-seven degrees.

It is, of course, necessary, to keep the inclination of the sides of earth embankments at a flatter slope than this angle of repose. The seaward slope is usually very much flatter than the landward; the greatest angle at which earth will stand, if undisturbed, may be taken for practical purposes at one-and-a-half to one, more

* "The Sea Dykes of Schleswig-Holstein." Min.Proc. Inst.C.E., Vol. xxi., p. 442.

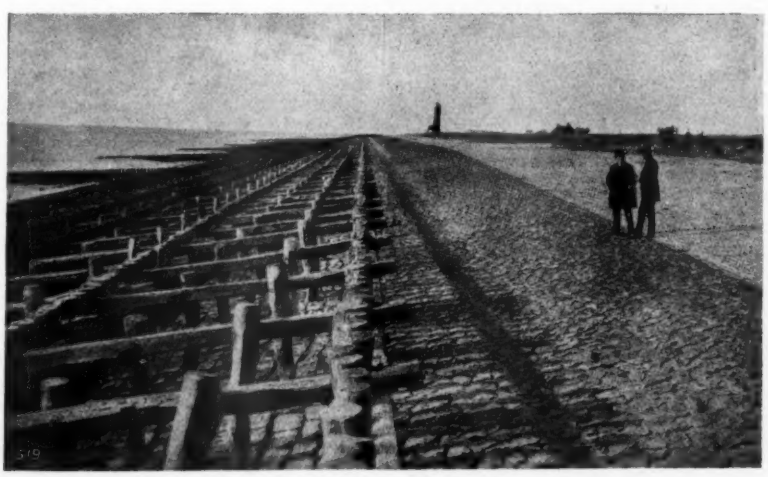


FIG. 3.—SEA BANK AT ZEALAND, SHOWING SLOPE PITCHED WITH BASALT, AND ALSO AN ARRANGEMENT OF TIMBER WAVE-BREAKERS NEAR THE BOTTOM OF THE SLOPE. FURTHER SEAWARD A CURIOUS TYPE OF GROYNE, HAVING OPEN SPACES BETWEEN THE PILES, CAN BE SEEN.

FIG. 4.—APRON OF SEA WALL AT BLACKPOOL, PITCHED WITH STONE, DIVIDED INTO BAYS.

usually the outward slope is something like three to one, and the inner about two to one.

In constructing earth embankments, they should be carried up in layers, not quite horizontal, but hollow towards the centre, and not more than one foot in thickness. All matter such as clean gravel, which might produce leakage, should be rigidly excluded. Each layer should be well rammed, or consolidated by carting over, and when finished ought not to be smooth on the surface, but rough and irregular, so as to bond with the next layer above; otherwise there is danger of leaving a plane of separation which will be a weak point in the work.

Gravelly clay is one of the best materials for constructing such embankments.

It is usually necessary, except in very sheltered positions, to protect the sea slope of earth embankments by an apron of concrete or stone pitching. When the latter is used, it should be cut up into bays or squares by short sheet piles, so as to isolate possible damage, otherwise, when once a breach has been made in the pitching the mischief will spread rapidly. Such pitching usually fails by the water getting underneath it, through the spaces between the stones, and washing the bed away; when this happens, the pitching sinks and is torn out. It is, therefore, of great importance that such pitching should be bedded on good impervious clay or concrete, and that the spaces between the stones should be thoroughly grouted up with cement grout. Kentish rag is much used on parts of the south coast of England for this purpose, but it does not stand attrition well. Hexagonal columnar basalt is an excellent material for facing embankments or sea walls with, owing to its great hardness and high specific gravity, as well as its shape, which permits of making fairly close joints without dressing. Its cost is about ten to fourteen shillings per ton, delivered in the Thames.

The toe of such pitched slopes is usually protected by a row of sheet piling, parallel to the bank.

There is a form of pitching used sometimes for the face of sea banks, when stone is plentiful and cheap, and in which open joints are purposely left. The pitching is, however, bedded upon a deep layer of broken stone. *Mr. Brunless describes the banks constructed by him as follows:

"He had usually adopted a slope of two to one for the sea face of the bank. The hearting was generally of sand, which was covered with a layer of puddled clay of twelve inches in thickness, and upon that, on the sea slope, was placed from two feet to four feet of "quarry rid" and broken stone, and afterwards the pitching, which varied from sixteen to eighteen inches in thickness. By placing broken stone immediately under the pitching, the waves did not run so far up the slope, nor were they so destructive when receding. The water in the advancing wave was dispersed, through the joints of the pitching, and received into the rid. It was with the object of making the receiving power of the rid equal to the quantity of water likely to break upon the slope that its depth was varied from two feet to four feet."

This form had been used in about thirteen miles of bank and had stood for several years without failure. It is curious to note how the same line of thought brings men to apparently opposite conclusions. Of course

* Min. Proc. Inst. C.E., Vol. xxi., p. 482.

the point is, we must either keep the water out altogether, or give it plenty of room to spend its energy in if it is admitted.

It may be said that earth embankments have their greatest field of usefulness in surrounding and reclaiming land from the sea, and protecting it from future inroads. In such cases the tendency of the sea is to retreat; but when it is really advancing on the land, earth embankments are useless as a protection.

Whenever they are used, it is of the greatest importance to build and keep them so high that they will not be overflowed by the very highest tides and the roughest sea. When this happens, they rapidly wash away.

(To be concluded.)

Results of Recent Experience in the Bacterial Treatment of Sewage.—IV.

By W. H. MAXWELL, A.M.Inst.C.E.

Materials for contact beds.—Failure of contact beds has frequently arisen through the use of improper materials. In some cases common gravel containing large and small material alike and even sand just as obtained from the gravel pit has been shot into the beds, and this without any adequate provision for either under-drainage or ventilation through the mass of the material. Nothing but failure could be expected from such a bed, more especially when crude or partially screened sewage is turned on.

In selecting and placing materials in the bed it must be remembered that the object is to expose a maximum of *surface* alternately to the sewage and to the air, so that there may be ample areas over which the bacterial growths may take place and with which the sewage and air alternately may come in contact. The material should be hard and tough and admit of the sewage and air alternately filling all its interstices. It should be strong enough to resist crushing through superincumbent weight. If the material is too much honeycombed and in large pieces, there may be a tendency to retain stale sewage in its crevices, and to reduce the capacity of the bed by holding back a large amount of liquid by capillary attraction.

The material should be well graded to uniformity of size and not be too large. All very fine stuff or dust must be sifted out or the bed will soon be choked as proper aëration is impeded. The beds should not be formed of layers of material of different sizes; uniformity throughout gives the best results.

The actual material selected in any given case will naturally depend very largely upon local conditions and facilities for obtaining a suitable medium at the lowest cost. Amongst those which have been successfully employed are good hard vitreous clinker, broken brick rubble, granite, flints, broken "saggers" from the Potteries, hard coal and coke. Slags from iron works should be used with caution, as they may be liable to disintegrate under the action of septic sewage, but the vitreous slags from cold blast furnaces have often been found suitable.

Carbonate of lime is soluble in the effluent from septic tanks and any material into which this enters largely will be liable to disintegration. The material used, therefore, should not effervesce under hydrochloric acid; it should be clean when put into the beds and be washed if necessary.

Where refuse destructors are in use the clinker obtained is very generally used for the purpose of forming both contact and percolating beds, as a convenient outlet for the material is thus afforded and the beds are filled at a low cost. The harder and more vitrified portions should be selected and all small stuff below one-eighth inch be taken out.

The size of material employed in many cases has been too large and results have justified the use of a smaller and more uniformly graded material. Large material does not necessarily prevent choking. On the contrary the present writer is of opinion that by its use a large proportion of the sewage is not brought sufficiently into

contact with the surfaces carrying bacterial growths to ensure the requisite purification, owing to the large interstices between the material. Although larger sizes are in common use experience tends to show that where a good hard clinker is used the sizes may with advantage be from 1½ in. to ½ in. gauge for the primary beds and ½ in. to ⅛ in. gauge for the secondary beds—it being assumed that a septic tank effluent is under treatment. A layer of coarser material, say 2 in. or 2½ in. gauge, may be placed immediately over the under drainage to facilitate aëration and drainage.

Good results have been obtained from coke both in regard to capacity of the bed and percentage of purification effected, but it is not so suitable as a good hard selected clinker owing to the greater tendency to break down or disintegrate.

Some clinkers, however, are attacked by the sewage, soluble matters are dissolved, and small pieces of disintegrated clinker will pass off in the effluent. When coke is used some trouble may arise from floating in the liquid. The "saggers" from the Potteries make an excellent material in localities where obtainable at a low cost. For dealing with a septic tank effluent fine gravel may be expected to yield a more thoroughly nitrified effluent than coarse gravel, but beds of suitable clinker may surpass either.

The idea of a bed consisting of a series of flat surfaces laid level has been put into practice at Devizes, where an experimental bed has been made of hard waste slate débris laid in layers supported one above the other by small slate blocks about one inch apart. The same principle is followed in the flat tiles, as made by Messrs. Hamblet, of West Bromwich, having ridges on the under side to separate one tile from the next above and below. By these methods a large water capacity is maintained, the likelihoods of choking are much reduced, consolidation of the bed is practically impossible, a large *surface* is exposed for bacterial growths, and the arrangement facilitates the washing or flushing out of the dry irreducible solids which may accumulate.

Distribution of sewage over contact beds.—The elaborate troughing of iron, zinc, wood, &c., complicated with notchings, holes, and adjusting screws, has now mostly been laid aside and simpler methods followed, seeing that no better effluent was obtainable by the aid of such distributing devices. In the larger works, as in the case of the Manchester contact beds, the sewage is admitted from the supply channel into a shallow basin or reservoir within the bed, and then passes over a semi-circular cell or weir on to the material of the bed, in which is formed a series of radiating channels or grips, into which is placed finer grade material to keep the grosser solids at the surface, and as the porous surface of these channels becomes choked, the sewage is gradually carried further forward before passing down into the bed. These channels are turned over from time to time as necessary, so as to vary their position. This method of distribution for contact beds is found to work satisfactorily, and has the important advantage of being exceedingly simple.

In many instances the sewage from the septic tank has been distributed over the bed by means of half-pipe stoneware channels sunk flush with the surface, so that the liquid may flow over the sides. These, again, provide a simple arrangement, but do not possess any real advantages over simply cutting the surface grips as above-mentioned, except, perhaps, for two or three lengths leading off from the outlet of the feed-siphon valve. In either case, the surface of the material of the beds may be practically at the same level as that of the sewage in the septic tanks, unless fall is required for aeration of the sewage, or for a long supply or storage channel. Whatever means of distributing the flow of sewage over the bed is adopted, it should be so arranged that the bed may be filled in about half-an-hour.

Double contact necessary.—Where a full bacterial treatment is required, in order that the effluent may be non-putrefactive and well within the recognised standards of purification, multiple contact beds are usually necessary. That is to say, an upper or first contact for the retention and digestion of the grosser impurities in the tank effluent must be followed by lower or second contact beds. These are respectively described as "coarse" and "fine" beds, according to the grade of material used, and as a rough approximation, it may be taken that the first or upper contact will remove about 50 per cent. of the dissolved impurity, and that the second contact disposes of some 50 per cent. of the impurity still remaining in the effluent. This conclusion was deduced from the Manchester experiments (1899). If single contact only is given, the effluent, generally speaking, will require further treatment, as, for example, upon good pasture land, as is proposed in the case of the Beaumont Leys Farm at Leicester.

It has also been shown that, where

double contact is considered to carry the work of purification farther than is absolutely necessary, a good non-putrefactive effluent may be got by subjecting say one-half of the sewage to double contact and the remainder to single contact only, and then mixing the effluents so obtained, thus securing what may be regarded as one-and-a-half contact. By this means the area of "secondary" beds required would be reduced proportionately to the mixtures of first and second bed effluents. The introduction of the nitrated effluent from the "second contact" into the septic tank itself has also been suggested.

With a system of "double contact" on the lines above indicated, the bulk of the work is found to be done upon the "primary" beds, and, in some cases, economy of construction has been effected by providing only half the area of "secondary" beds; that is to say, the effluent from the first beds is passed through the final beds at twice the rate of the former. At Burnley it was found that when the effluent from the upper beds was passed through the lower beds at twice the rate, a good final effluent was still being obtained. This possible reduction in area of the secondary beds is, however, not recognised by the rules of the Local Government Board, which require that the area of the "fine" beds should equal that of the "coarse."

The works for the treatment of the sewage of Yeovil provide for double contact in respect of dry-weather sewage, but upon the increase of the flow beyond the capacity of the upper beds, the secondary beds also are then brought into use for first contact. The effluents from both first and secondary beds are passed on to high and low level irrigation areas.

Percolating beds.—The percolating bed, as a means of final purification of septic tank effluent, is a more recent development than the contact bed, and, at present, appears to be growing in favour. As has already been indicated, the essential feature of the percolating system lies in the method of applying the sewage to the bed. This is accomplished in a continuous rainlike manner by means of "sprinklers" revolving on the Barker's mill principle, in a horizontal plane, or by means of jets or nozzles placed in rows of fixed pipes carrying the sewage. In some cases the same object is accomplished by distributors travelling on rails, and carrying a series of jets arranged to embrace the full width of the bed. Whatever the method of applying the sewage, the object sought in all cases is to bring about a uniform distribution over the whole surface of the bed, so that it may percolate through by dripping slowly from particle to particle of the filtering material, and thus become thoroughly exposed to the air and the nitrifying influences of the bed.

The "Bryan" sprinkling jets, fixed in 3 in. diameter distributing pipes, working under a 5 ft. head of water, give good results, and appear to meet every requirement at a much less cost than the rotary sprinkler. These jets are largely used at Birmingham, and are being adopted at Malvern and elsewhere.

The question of nuisance from smell occasioned by the continuous spraying of septic sewage in the air, is an important factor to be considered in the great majority of works. For the satisfactory spraying of the sewage, it is necessary that it be first freed from as much suspended matter as possible to facilitate the working of the distributors, and the effluent from the bed, though well nitrified and otherwise in good condition, usually contains a considerable quantity of suspended particles, consisting of humus and washings from the clinker or other material of which the bed is formed. This must be removed before passing the effluent to the stream, and for that purpose the effluent will require to be passed over land or through a sand filter.

Distributing apparatus for percolating beds.—The various types of distributing apparatus for percolating beds now in use may be roughly classified as:—Balanced trays or tippers, fixed pipe distributors, sheet iron gutters or troughing, travelling spray distributors, and rotary sprinklers.

Of the first class, a series of tipping trays, spaced at short intervals over the whole filter, have been used by Colonel Ducat and Mr. Scott Moncrieff. Fixed pipe distributors have been introduced by Mr. J. Corbett, the borough engineer of Salford, on a large scale, and are now in use at a great many places. These may be fed either direct from a storage channel under a small head of a few feet, or, in some cases, the feeding to the sprays is done by automatic tippers, or by "ejectors" discharging at fixed intervals, as done at Chesterfield. Here, at each discharge of the ejector (Shone's), 100 gallons of sewage is forced by means of compressed air through $\frac{1}{8}$ in. to $\frac{1}{4}$ in. holes, spaced at from 3 to 4 ft. intervals along the iron distributing pipes, which are placed over the bed 3 or 4 ft. apart. The sewage impinges with great force upon pieces of iron hooping, and is thus intermittently sprinkled over the

whole surface of the bed. Although effective, the use of compressed air for the distribution of the sewage appears to the writer to be too costly for application on a large scale, and the large amount of fine spray thrown into the air would doubtless be a fruitful source of complaint from smell in the great majority of sewage works sites. Of sheet iron gutter distributors or troughing, are those introduced at Salisbury, Knowle, and elsewhere by Mr. Stoddart, of Bristol, and that put down at Hucknall by Mr. Orange, of Nottingham. The "Stoddart" distributor is made of corrugated sheet iron of special design, and has numerous holes punched through to allow the sewage to drip uniformly on to the beds from the small points thus provided.

The rotary type of distributor has now become quite a familiar object, and is being extensively used in many places. Well-known makes are the "Candy-Whittaker," Adam's "Cresset," and Mather and Platt's.

An important practical point in connection with rotary sprinklers is the amount of head required to properly work them. This generally varies with the length of the arm or diameter of the bed. Commonly a head of about 18 in. is required for a 30 ft. distributor, and this should be increased to, say, 3 ft. 6 in. for a bed of 125 ft. diameter. At the Buxton bacteria beds are seven Adam's "Cresset" revolving sprinklers of from 58 ft. to 96 ft. diameter, all of which have worked satisfactorily with a head of 18 in., which is the minimum at which they will work satisfactorily. The depth of the beds is 4 ft. 6 in. and 6 ft., and the effluent is satisfactory. The depth of all the beds is intended to be brought up to 6 ft. as the material is produced.

Rotary sprinklers cease to work satisfactorily when the quantity of sewage passing through them falls below a certain rate per square yard of filter per day, so that no such sprinkler should be fixed on a shallow bed incapable of satisfactorily dealing with the sewage at that minimum rate.

Amongst the "travelling" class of sprinklers are those of Scott-Moncrieff, as used at Saltley in connection with the Birmingham Tame and Rea district drainage; the Willcox and Raikes distributor, as installed at Hanley; the "Fiddian" distributor; and Messrs. Ham Baker & Co.'s automatic traveller.

The "traveller" class pass over the bed either upon parallel rails or by means of a rotary motion, the outer end of the distributor running upon a circular rail. The motive power may be either gas, oil, or electric current, according to local facilities. The "Fiddian" patents relate to distributors in which the water-wheel is employed to drive the sprinkler and to spread the sewage. A feature of the "Fiddian" distributor is that it is designed to work with a small head and with slow feeds. The head required varies but little with the diameter of the filter, and, measured from the water-level in the detritus chamber to the top of the filtering medium, need not exceed 14 in. For a filter of 125 ft. diameter, an 18 in. head is sufficient, whatever the rate of flow may be.

Some difficulty frequently arises in distributing the sewage uniformly over a bed by means of rotary sprinklers unless the rate of flow is in excess of that with which the bed can at all times efficiently deal with, owing to the unreliable working of the sprinklers at the lower rates of flow. It is largely on this account, perhaps even more than on account of the bacteriological aspect of the question, that sprinklers have latterly been introduced for working on the intermittent principle—that is, with alternating periods of rest and work, each of some three or four minutes' duration. Although this intermittence may have some effect in the direction of preventing the growth of the pilobolus on the surface of the bed, and so reduce the chances of clogging, it has also to be borne in mind that the sewage, in consequence of the intermittence of the spray, passes through the bed in rushes and so tends to carry off more suspended matter in the effluent.

(To be continued.)

Air in Relation to the Efficiency of Surface Condensers.

By JAMES A. SMITH.

To some extent this paper, which was read before the Victorian Institute of Engineers, is a sequel to a former paper, dealing with "Air in Relation to Boiler Feeds," read before that Institute on June 4th, 1904. The principal object is to contribute to the knowledge of an imperfectly investigated subject fundamental data derived from direct experimental researches by the writer. The aim is to stimulate discussion and examination of hypotheses that have been accepted upon premises that are no longer sufficiently accurate to meet the exigencies of modern design. The key-note is the effect of gases —specifically atmospheric air—upon working efficiencies and capital investment.

The chief deduction is that air, even in minute traces hitherto considered innocuous, should be, by initial design and subsequent management, rigorously excluded from high-grade surface-condensing installations. Certain laws of condensation are also enunciated.

Preliminary.

Steam-engine practice is inferred throughout. The method of extending the deductions to the condensation of steam for potable water, or vapours for manufacturing processes, will be obvious.

Even a superficial glance reveals the inadequacy of the older data. First, because the trend is to expand steam to degrees undreamt of in the past, when those data were collected, and to reject it at temperatures so low that crude rules, simply embodying obsolete average conditions, are useless. Second, because it appears to be tacitly assumed that generalisations derived from incomplete investigations of pure steam are equally, and without modification, applicable to mixtures of steam and gas.

Experiment shows that such assumptions are fallacious, and that the presence of air in quantities that might have been deemed insignificant may, in fact, become the factor limiting the efficiency of a whole steam plant. For instance, air equal in pressure to only $\frac{1}{10}$ in., by the mercury gauge, will at 90° Fahr., reduce thermal transmission some 25 per cent., whilst $\frac{3}{10}$ in. will lower it about one-half. Before these special effects could be determined it was necessary to investigate the whole subject of surface condensation.

Effect of Condenser Temperature upon Engine Efficiency.

The necessity for dealing with the main issue will be inferred from an elementary analysis of the effects upon thermal efficiency of the reduced temperatures aimed at. It must, however, be clearly understood that in the cases of engines, reciprocating or rotating, not specially designed to utilise these temperatures, it may be inadvisable to attempt their use. When there is a notable fall in density between the points of release and condensation, the consequent increment of piston load may be incommensurate with the cost requisite to transmit the heat, at a lower temperature difference, to the cooling water.

Modern practice differs in the cases of cylinders or their equivalents exposed alternately to hot and cold steam, in degree only from the old Newcomen method of injecting water into the cylinder. The question is one of compromise. Each instance requires individual evaluation, and in the cases alluded to, cylinder condensation, and reduced temperature of hot-well boiler feed, will neutralise vacuum effects pushed beyond a certain point. It is otherwise when steam can be expanded—constantly performing useful work—down to condenser pressure; then every consequent fall of temperature is accompanied by a corresponding gain in thermal efficiency. The reason that the road of improvement is by the way of reduced final temperatures is that energy in thermal form, or "heat," is the capital of the power engineer, and that the theoretical efficiency of any ideal heat motor, of whatever design, and whether using steam or any other medium, depends ultimately upon the proportion of that

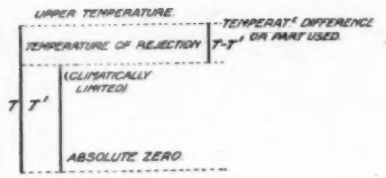


FIG. 1.

capital transformed into its equivalent of mechanical energy.

The thermal capital of a given mass is measured by its temperature referred to absolute zero, or 461° Fahr., and the efficiency of any ideal engine using the mass is determined by the ratio of the temperature fall (thermal capital used) to the initial absolute temperature. When T equals the initial, and T^1 the final absolute temperatures of use, this is expressed by the well-known equation

$$\text{Efficiency} = \frac{T - T^1}{T}$$

It is the ratio of the part used (fall, or difference of temperature) to the initial (capital) temperature. Graphically, it may be delineated as in Fig. 1.

The hydraulic analogue is a perfect turbine situated between an elevated water-source and the sea. At the exact source level no power can be derived; at the sea all can be used. At intermediate points the effective head is that above the turbine, and the proportion of that to the whole potential head, referred to sea-level, is the ratio of possible efficiency. It may be absolute if the turbine is at sea-level, or if the source is at an infinite height. Similarly, thermal efficiency may be absolute if the initial temperature is infinite, or the final temperature is zero absolute. Of course, both extremes exist in theory only; but approximation to the latter is, in practice, easier than to the former.

If the fractional expression $\frac{T - T^1}{T}$ is examined in this connection, it will be observed that the denominator (T) is constant, whilst the numerator ($T - T^1$) is variable. If, then, T^1 is varied by equal successive steps, a series in arithmetical progression results that may be typified by $\frac{0}{10}, \frac{1}{10}, \frac{2}{10} \ldots \frac{10}{10}$. Hence each equal decrement — utilised — of temperature causes equal increments of efficiency, if the initial temperature remains constant.

The subjoined table shows the extreme desirability of utilising to the utmost the lowest temperature consistent with the climatic environment, and this is only possible by perfecting the condenser.

THERMAL EFFICIENCY IN RELATION TO THE LOWER TEMPERATURE LIMIT. UPPER LIMIT CONSTANT AT 371° FAHR. (= 160 GAUGE POUNDS OF STEAM, NEARLY). REFERRED TO THE DUTY WHEN REJECTED AT 212°.

Lower Temperature.	Differences.	Efficiency Increments	Differences.
deg. F.		per cent.	
140	...	45·27	
130	10	51·56	6·29
120	10	57·85	6·29
110	10	64·14	6·29
100	10	70·43	6·29
90	10	76·72	6·29
80	10	83·02	6·29
70	10	89·31	6·29

NOTE.—At 212° 140° and 70° the absolute thermal efficiencies are respectively 0·191, 0·218, and 0·362. In a diagram both temperature and efficiency are straight lines.

Physical Basis of Condensation.

It is not necessary that this phase should be exhaustively treated, but it is essential that the line of thought underlying the actual experimental work should be comprehended, although those who so desire may confine their attention to the experimental section of the paper upon which the conclusions are based. Steam or gases alike are masses that were, at a previous period of their physical history, fluid. They differ from liquid in that energy has been imparted to them in such a manner that the mean free paths of the component molecules between collision have been extended; as a consequence, the volumes reserved by individual molecules have been increased, and, as a further consequence, the volume of the mass, as a whole, has enlarged. The rate of molecular motion is apparent as temperature, the rate of molecular bombardment upon unit area of the containing wall as pressure. Were steam contained in a vessel such that the molecules of that vessel completely restored to the steam molecules the energy of impact, then the steam energy would remain for ever imprisoned and potential, if radiation through space free from non-ponderable matter be excepted—and in relation to condenser work it may be eliminated. If the co-efficient of restitution is imperfect—as it always is—then a portion of the internal energy of the steam passes to the molecules of the walls, and thence to any interlinked cooler environment furnishing an energy sink.

Thus the original evaporation cycles are reversed. But in the case of each fluid

that may become a recondensable vapour, or each vapour that may become a fluid, there is a sharp demarcation between the states. Given a vapour differing insensibly in temperature from that of its fluid at the same pressure, then it is at its critical point, and the slightest abstraction of internal energy through the walls of the containing vessel will determine the liquefaction of a portion, strictly in accordance with the energy transferred. Thus, in the case of pure saturated steam—that is, steam at its critical point—in contact with an energy-absorbing or cold surface; the most intense volume change, where the latent heat is given up, or the molecular paths alter in extent from that traversed as steam to that traversed as water, is immediately at the surface. The rates of increase of the paths of the relatively great numbers of residual molecules at any instant is relatively insignificant.

In the case of steam, given the energy sink, the chief limit to the rate of change is the time required for the internal energy existing as molecular motion in all directions to become, in part, energy of motion in one general direction of approach. In respect to the walls it is the transmitting capacity of the molecules that is the thermal conductivity of the solid.

"Permanent" gases do not even remotely approximate to their critical point at condenser temperatures. There is no selective reduction of a portion of the molecular paths, but a general (though slight) reduction of all as a consequence of cooling, and the change is accompanied by a motion of approach negligible relatively to that of steam.

Logically it follows that the condensation of pure steam, and of steam mixed with a permanent gas with which it does not combine chemically, is radically diverse.

Steam progresses continuously towards the surface, where it becomes water, passing away in that dense state, almost without resistance, as drops or a gliding film. The inter-diffused gaseous molecules are impelled towards the same surface, but in that direction they cannot escape.

Dalton and Graham's laws of partial pressures and diffusion make for homogeneity of mixture, but they are rigidly true only when the volume is statically constant; here the conditions are dynamic. The result is ultimate equilibrium, but not homogeneity.

Since the steam condensation is chiefly evident in a lamina of minute thickness at the condensing surface, it follows that, given a moderately rapid motion of general approach, then, although the gas may at first be highly tenuous, a very slight retardation of diffusion may permit of an accumulation of molecules at that laminar focus of energy change, when their impedance is a maximum.

To qualitatively study some of these phenomena, the author uses closed glass tubes containing bromine, both with and without air in the vapour space. The low boiling-point, deep non-actinic colour of the vapour, and strong russet-red of the condensed films, render it easy to follow the processes of diffusion and condensation, and photograph the results.

Basis of Experimental Research.

Clearly the fundamental basis of investigation is a study of the retardation of diffusion of gases entrained in steam possessing motion of translation in space.

The question, when complicated by the conditions essential to practice, is most complex, and it did not appear that there were sufficient data to permit of mathematical solution; therefore it was determined to investigate the various phenomena experimentally. This was found to entail a very considerable amount of work before non-essentials could be eliminated.

Quantitative records, to be reasonably accurate, require that the exact temperatures and partial pressures of the steam and gases, the temperature and mass of the cooling water, and the condensing superficies shall be known and shall be constant or variable at will. The rate of metallic thermal transmission, gaseous solution in fluid, gaseous thermal conductivity, and other matters must either be determined or eliminated.

It is hopeless to expect that these requirements can be met by experiments upon condensers in actual use, although such tests have great value in other directions. It was decided to deal with the matter on a scale that permitted the omission of non-essentials whilst retaining in isolated form those functions approximating as closely as possible to the essentials. After considerable tentative work, necessitating some hundreds of tests, the author rested in the construction and methods to be described.

The experimenter should, in a matter of this nature, possess previously-acquired manipulative skill—especially in thermometry—and should familiarise himself with his apparatus until that manipulation becomes instinctive and sure.

No attempt has been made to deal with

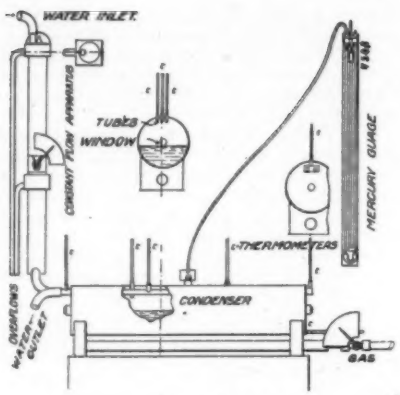


FIG. 2.

abnormal states of scale or oil films. In practice such uncertain, possible conditions are met by a large excess of surface at enhanced cost. Higher future efficiency of standard plants should raise the ideals; and, even by a purely initiative process, minor plants should be improved in these respects.

Essential Conditions.—With a finite condensing surface, and a constant rate of flow of cooling water over that surface, the water temperature increment is the basis of the relations sought. To enable the information to be gleaned, and the variations to be codified, the following experimental conditions must be attainable:—

(*a*) Partial vacua within the range of probable condenser practice.
(*b*) Any relation of steam to gas partial vacua.
(*c*) The various constants not to be affected by the progress of the experiment.
(*d*) Temperatures and pressures to be controllable with considerable exactness.
(*e*) Constant flow of cooling water at a predetermined rate and temperature.
(*f*) The temperature of flow to be determinable at points intermediate between the initial and final.

Apparatus.

Generation of steam in a vessel distinct from the condenser is inadmissible when vapour mixtures are in question. The equivalent of an indefinitely great vaporous atmosphere of constant composition is required. If a separate boiler is used, whatever the original composition of the mixture, the continual undirectional flow of the steam will cause a varying and unknowable concentration in the condenser. If the condensed water accumulates, the condenser volume and vapour distribution will vary; if drawn off, a complication of apparatus follows, with great danger of air admission. Further, absorbed gases will be withdrawn in aqueous solution to an appreciable amount during a long series of tests.

In the apparatus before the Institute, and illustrated by Fig. 2, the condensing tubes pass through the steam space of a boiler, and constancy of the condition of the mixture is practically complete.

Containing Vessel.—Length about 3 ft., diameter $7\frac{1}{2}$ in.; No. 19 B.W.G. galvanised sheet steel, strengthened by one central ring of 1 in. by $\frac{1}{4}$ in. steel; intentionally made light, in order that temperature lag may be minimised. The joints are folded, soldered, and tarred. This must be carefully done. It is most difficult to completely exclude leakage; solder alone will not do so. By leakage is meant the admission of sufficient air to reduce the mercury gauge level, say, $\frac{1}{50}$ in. in 24 hours.

At either end there is an axial opening glazed for observation by slightly taper glass plugs with polished plane faces. The plugs are cores cut from $\frac{3}{4}$ in. polished plate glass by a rotating brass tube and 70-hole carborundum; the joints are made tight by sleeves of pure rubber tube smeared with melted rubber, and then inserted with the plugs in slightly conical brass tubulatures. A small stop-cock, with a $\frac{1}{4}$-in. shank, screwed into an opening in the shell, is the only other non-positive sealing, and this is enclosed in a vessel of water to prevent air ingress. Connection is made to the gauges, &c., by sound new thick-walled rubber tubes of $\frac{1}{16}$ in. internal, and $\frac{1}{4}$ in. external diameter.

Heating Arrangements.—In the first types of apparatus boiling was effected by steam passed through internal tubes, the intention being to measure the steam condensed. It was found that numerous corrections and adjustments rendered an apparently simple system uncertain; subsequently heating by gas was adopted, and is quite efficacious. A horizontal mixed air and gas tube of $1\frac{1}{2}$ in. diameter extends beneath the whole length of the containing vessel; it is perforated by sixty apertures in two rows; each jet is $\frac{1}{8}$ in. in diameter. The temperature is adjusted and maintained constant by varying the gas by a stop-cock, with a pointer attachment

traversing a graduated quadrant. This, with a pressure-regulator in the service supply, is sufficient to ensure constancy to $\frac{1}{10}$th deg. Gas up to 45 cubic feet per hour is necessary.

Condensing Tubes.—There are two of these connected in series. Each is a little more than 3 ft. long; the total effective length is therefore rather more than 6 ft.; the external surface exposed to the vapour is exactly 1 square foot. The external diameter is about $\frac{5}{8}$ in., the thickness is 0·018 in., and the sectional area of the bore is 0·26 of one square inch.

The tubes are hard mandrel-drawn brass; the surface is a draw-plate one, clean and smooth, but not polished in any way. The thermal conductivity depends upon the thickness, chemical composition, and physical state of the material of the tube, and the temperature and mass of the flow. To avoid the difficulty and uncertainty of determining some of these factors, the whole were conjointly dealt with by passing water at 32°, from melting ice, at the rate of 5 lb. per minute, through a piece of tube cut from the same length as the main tube, and surrounded by pure steam at 212° Fahr.

The short tube was $\frac{1}{10}$ of the length of the condensing tubes and exposed $\frac{1}{10}$th of one square foot of cooling surface. Sixty-seven British thermal units were transmitted per minute, and this supplies the basis for comparison for other metals and states.

At each foot of effective length a perpendicular branch tube penetrates (except terminals) through the steam space and shell. Through these a small-bulbed thermometer can be inserted through a cork jacket into the main tubes, in order that intermediate temperatures can be ascertained. Long cork plugs, flush with the tube bore, close the openings when not in use.

Constant-Flow Apparatus.—It is necessary that the rate of flow shall be adjustable, and that it shall be accurately measurable. The constant-flow apparatus (Fig. 2) was devised to this end, and answers perfectly.

It consists of a vertical tube, closed at the bottom, into which an excess of water is delivered by a perforated tube in a non-eddying manner; the excess escapes over the upper lip. A stop-cock (with carefully-polished ports), together with a long pointer and graduated arc, allows definite flows to be drawn off and discharged into a second tube connected with the condensing apparatus. The graduations were made at each $2\frac{1}{2}$ lb. per minute, from $2\frac{1}{2}$ lb. to 20 lb., and were carefully and repeatedly calibrated by weighing the discharges during ten to sixty minutes.

Vacuum Gauges.—Various types were tried; the difficulty is the deposition of condensed vapour. Closed U gauges—barometer and gauge combined—give direct readings, but soon lose accuracy, from the creeping of the water film into the Torricellian space. To substitute a known for this unknown variable water was introduced in excess, also a large chamber containing a perfect water vapour vacuum was attached, and the corrections for temperature made. Ultimately a simple open U gauge, shown in Fig. 2, was adopted. No capillary correction is necessary, and with thin glass parallax is negligible. The mercury must be pure.

Barometer.—The form of gauge used requires the use of a comparison barometer. In order that the readings shall be true, the tube is filled with pure mercury, and this was boiled thoroughly in place.

Thermometers. — These were carefully checked against a reference instrument, itself compared with instruments certified by the Imperial German Testing Laboratory. The Victorian Government Astronomer (Mr. P. Baracchi) also kindly compared one of the instruments with his standards.

Note.—Purchased instruments can only be regarded as arbitrary and, perhaps, irregular scales until the necessary corrections have been ascertained by comparison with an assured standard or gas thermometer. They may be very considerably in error from a number of causes, so also may barometers. The only security is to construct or calibrate them personally or supervise the work, unless the investigator can obtain them direct from a maker of repute, together with a certificate of performance.

Method of Use.

The Vacuum.—The stop-cock is removed and the shell filled to the upper level of the observation window with pure water. The stop-cock is again inserted, the air pumped out by an ordinary air-pump or syringe to about 1 in. mercury pressure, the gas-jets lit, and the water heated until the gauge or thermometer indicates a positive pressure, then the stop-cock is removed and the steam allowed to escape at about 2 lb. to the square inch, until the water-level has fallen to the lower edge of the observation opening. The stop-cock is then replaced, a partially perforated rubber cork placed upon the exposed shank, the whole covered with water, and the gas turned off. When cool, an almost perfect water vapour partial

vacuum will result, in which the water readily boils at 70° Fahr. Water may be drawn in to the vacuum at any subsequent period; but when this is done, boiling must be again resorted to, as described, to drive off air held in solution. The routine must also be repeated when it is requisite to eject air or gas which may have entered or been added. It is well to prevent, as far as possible, the access of full atmospheric pressure to the water surface. The water should be under vacuum between experiments.

Added Gas.—This may be drawn through a capillary tube of about $\frac{1}{100}$ in. bore, attached to a rubber tube with pinch-cock, connected to a branch in the gauge system, and the amount determined by gauge readings.

Or, without reference to the gauge, measured quantities of air may be drawn from a graduated vertical burette with the lower end immersed in water. The partial pressure is computed from the known volume, remembering that in this connection the steam behaves as a perfect vacuum.

A third method—that preferred—is to insert a capacity in the gauge circuit, so that a known volume—*i.e.*, that of capacity, gauge, and tubes—can be drawn in, and the result checked against the gauge reading.

The advantages of the direct addition methods are their certainty, and that they can be made irrespective of condenser temperature corrections, which may be considerable, due to the presence of hotter or colder water in contact with the vapour. This should be specially remembered when testing actual condensers. Minor corrections may be required for the atmospheric condition of the gas admitted.

Determining the Gas Pressure by Gauge.—The detail of the gauge (Fig. 2) is self-explanatory. The measuring-rod is graduated in inches, carries at its lower extremity a fixed index, slides in a socket, and upon it there slides an adjustable index, with a short scale attached. The indices are adjusted to the upper and lower mercury levels—the glass tube is thin to minimise parallax—and the difference read off.

The gauge reading is subtracted from the barometer reading at the time. The difference is the absolute pressure exercised by the vapour in the condenser; it may be wholly due to water vapour, or partially to gas.

By Dalton's law the presence of gas does not affect the pressure of steam also, or previously present, and *vice versâ*. Each component is to the other as a vacuum, and the total pressure is the sum of the partial pressures. Steam pressures for all temperatures within condenser range have been most carefully computed;* therefore, if the pressure due to steam at the given temperature be deducted from the absolute pressure, found as described, the difference, if any, is the pressure of gas present.

There is one warning that must be most explicitly given to the prospective investigator. Dalton's law is true only when the temperature of the apparatus, the vapour, and the water is in equilibrium. The point appears to have escaped notice in those works that the author has perused.

Here is an illustrative experiment, in which, owing to the progress of condensation, the conditions are not static:—

Air present, by measure and gauge, at ...	70° = 0·49″
Water temperature	130·0
Vapour temperature	139·5
Difference	9·5
Mean...	134·7
Difference of barometer and gauge	5·60″
Partial pressure due to steam at 130° = ...	4·50
Apparent partial pressure of air	1·10″
	5·60″
Pressure of steam at 139·50° = ...	5·76
Apparent (impossible) minus pressure of air	0·16
	5·60
Pressure of steam at 134·7°	5·10
Apparent pressure of air	0·50
Air again found by gauge at 70° = ...	0·49

All parts in equilibrium.

Dalton's law was also found, experimentally, to hold at other and higher temperatures, provided there was complete equilibrium. The erroneous results that may be arrived at in actual practice are sufficiently obvious. It will also be noted that the law that a saturated vapour and its fluid in contact are at the same temperature ceases to be invariably true when gas is present.

Determinations by the gauge method must be at a complete equilibrium of temperature, and should be at the lowest temperature conveniently attainable, since then the ratio of gas pressure to steam pressure is highest. The gauge and connections are exhausted by syringe before coupling finally to the condenser; and during prolonged tests they are disengaged, and the stop-cock sealed as previously described, as air will pass through the pores of the rubber tube. The gauge should be lightly tapped during a reading.

* Regnault's tables, for instance.

Water Flow.—Assuming that the condenser contains a vapour mixture of the desired composition and temperature, the cooling water is permitted to circulate and the gas flames manipulated to maintain the temperature constant. The admission of air into the cooling current, especially at low rates of flow, must be guarded against by suitably constricting the discharge. Temperature differences are then recorded.

Plotting Data.—The readings were to $\frac{1}{10}$° Fahr., and $\frac{1}{100}$ in. mercury; the aim was final accuracy within $\frac{1}{4}$° and $\frac{2}{100}$ in. Very many tests were made. Those not concordant were rejected, as it was held that the mean of diverse tests differing from, possibly, different causes would have less value than good individual tests not thus smoothed. Flexible or plastic splines are better than French curves in the actual draughting work. There is a tendency with set curves to slightly adapt the line to the templet, and not the converse.

Results.—These may be classified thus:—

Vapour { Air admixture. / Temperature.
Tube lengths or temperature grades.
Cooling water { Rate of flow. / Initial temperature. / Final temperature.

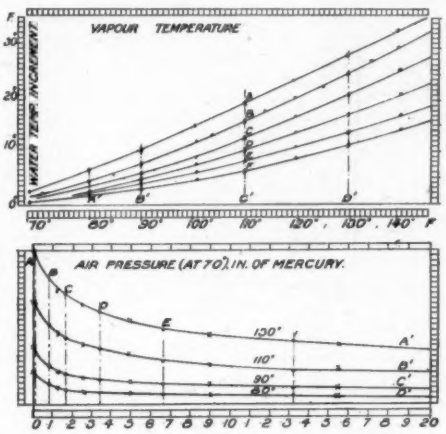
Typical cases in each division will be given.

Vapour: Simple and Compound.

To determine the effect of air admixture, two distinct methods were put into practice, and the results compared. In the first, pure, or nearly pure, steam was condensed at temperatures varying from 70° to 140°, at 10° intervals. The tests were fixed point observation, not running readings. Then the mixture was varied by adding air, and the process repeated.

In the second method the condenser was maintained at constant temperature, whilst the air in the mixture was varied by definite increments. The process was repeated at various temperatures.

In both series the cooling water flowed at the constant rate of 10 lb. per minute, and the cooling surface was 1 sq. ft. All matters were in equilibrium before a record was made. The results of a set of tests by the first and second methods are plotted, and the stations connected by curves in Figs. 3 and 4 respectively. The curves are interrelated. The curves in either figure correspond to the ordinates in the other; the distinctive mark (dot or cross) of either transferred to the other shows the approximation of the results, and this is sufficiently close to indicate that there is practically no serious cause of error existent. In both



FIGS. 3 AND 4.

figures the perpendicular ordinates measure increment of the cooling water temperatures, in Fig. 3 the divisions of the base are vapour temperatures; in Fig. 4, air partial pressures.

Discussion of the Results.—The air partial pressures are reduced to 70°; therefore, at all other temperatures the ratio will be different, but finite. The reduction then required is as follows:—531° absolute: absolute temperature at x° :: pressure at 70°: pressure at x°. The correction for variation of specific heat of the cooling water is negligible.

The correction when the temperature differences are not measured from the same initial temperature will be apparent when "tube length" has been considered.

With nearly air-free steam the line (*A*, Fig. 3), of temperature increment or efficiency of surface, is nearly straight when the vapour-temperature increments are equal. The slight curvature at the lower limb of *A* is due to traces of air; it increases with each addition, although not in direct proportion (*vide* curves *B*. . . . *F*).

With constant flow and surface and pure steam, temperature increment of the cooling water is in a constant ratio to the temperature increment of the steam, at least to a first approximation.

Corollary I.—The rise in water temperature is proportionate to the initial steam and water differences of temperature.

Corollary II.—Each decrement of condensor temperature requires a proportionate increment of cooling surface.*

* Provided the tube length is constant. See "Tube Length."

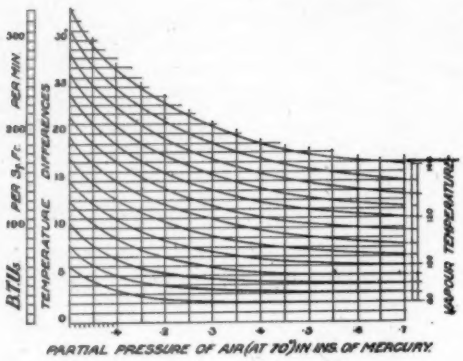


FIG. 5.

The ordinates to any of the curves measure the relative efficiency of unit area of cooling surface under the conditions premised.

Since the partial air pressures increase much less rapidly than steam pressures, as the temperature rises, the curves of mixtures tend to straighten to a greater inclination, implying an increased efficiency. The law relating to added gas (or air) is not clear; it may be simple, but the problem is involved. The writer has not succeeded in formulating a satisfying equation; therefore the data has been plotted in such manner that they can be utilised pending the discovery of the law.

Combination Diagram.—In Fig. 5 the observed results shown in Figs. 3 and 4 are combined. The constant basis is 10 lb. flow of water per minute. The vapour mixtures range from steam, with traces only of air, to steam plus 0·7 in. (mercury pressure) of air at 70° and vapour temperatures from 80° to 140°.

Divisions of the base refer to partial pressures of air; those of the left-hand scales, and the corresponding ordinate lengths, to temperature increment of the cooling water, and the B.T.U. transmitted per 1 sq. ft. per minute by the tube already specified. The curves are isotherms, each relating to a finite temperature, shown by the scale to the right.

Discussion of the Diagram.—Co-ordinates drawn respectively to the perpendicular O'' and the base, and the curve meeting them at their point of intersection, give, respectively, partial pressure of air, temperature increase of the cooling water, and vapour temperature. Hence, if any two of these factors are given, the third is evident by inspection; and if one alone is given, any one of an infinite series of interlinked pairs of remaining factor values can be selected.

Since the ordinates are measures of temperature rise, and therefore of efficiency, it follows that any line drawn parallel to the base cuts the curves in points of equal duty. Hence the relative economy of any particular examples or conditions can be directly compared.

Space does not permit an extended enumeration of the properties and application of the diagram; therefore a few salient points only will be noted:—

(*a*) The rapid rise of the curves from right to left denotes that the retarding effect of successive additions of air proceeds at a rapidly diminishing rate: this is more marked, in proportion, at lower temperatures. In fact, referring to the 90° curve, it will be seen that 0·2 in. pressure of air may almost exhaust the refrigerating power of a condenser.

(*b*) Equal increases of temperature of vapour at perpendicular O'' (or the pure steam line) cause equal rises of the cooling water temperature (this has already been explained when treating of the *A* line, Fig. 3), but the relation holds nowhere else. Towards the right the proportion decreases with decrease of temperature.

(*c*) The approach of the higher temperature curves to parallelism to the base is much less abrupt than the lower, indicating that the relative loss of efficiency by air addition is not so rapid as in the latter. But the absolute B.T.U. loss is much greater.

(*d*) The surface required is inversely as the cooling effect; therefore the difference in design between such limits as a condenser at 140° with pure steam, and one at 90° smothered with 0·3 in pressure of air, is obvious. In this example the effective ratio is about 7 : 1.

Tube Length, or Temperature Grades.

Frequently it is stated that the cooling water final temperature varies directly as the tube length, and that the average temperature is the arithmetical mean of the extreme. Were this correct, then, with an evanescent difference between water and steam temperature, the effect would be the same as when the difference is, say, 100°; obviously an impossibility. Condensers are made with tubes in series, giving a

length of flow of 30 ft. or more, and that when circulating water is abundant. This might be good practice if the preceding assumption were true, but it will be shown that it is fallacious; therefore the question of long tubes requires reconsideration.

The Law.—To determine this, a large number of distinct tests were made of the temperature increment at each 1 ft. (seven points in all) of the 6 ft. tube of the experimental condenser. Various temperatures between 70° and 140°, and mixtures from 0 in. to 1.5 in. of air were experimented upon.

When plotted and compared they were found to conform, within the limits of experimental error, to a very simple law, that may be expressed thus:—The differences of temperature between the vapour and the cooling water form a geometric series, of which the initial and final differences are the first and last terms. Shortly, the curve is logarithmic, vapour and water differences progress geometrically, and their ratio to water temperature increment is, apparently, constant for a given vapour temperature and mixture.

If at each point the increment of water temperature is proportional to the temperature difference causing it (*vide* Fig. 5), then the hypothesis of geometric progression (in decreasing order) is the direct sequence of continued cumulative action by a vapour at constant temperature upon water—*i.e.*, flowing in a tube.

Actual numerical working of geometric series is given in the Appendix.

Typical Diagram.—The small preliminary diagram in Fig. 6 shows the relation of the observed points to computed curves in two sets of tests, one with nearly pure steam, the other with 0·22 in. air (mercury gauge) added. Vapour at a constant temperature of 110°, water at a constant flow of 10 lb. per minute.

The observed curves, designated *A* and *B* are plotted in the main portion of the diagram, and the computed curve extended in dotted form.

Discussion of Curves.—Curves relating to other cases within the range of Fig. 5 may be plotted, if the initial and final cooling water temperatures are selected, and the intervening points computed; or the exterior points may be extrapolated after finding the common ratio; and in that case the results for any tube length become available when those for a short tube are shown.

Difference of ordinates (measured to the steam, not base, line) successive differences in the series, or the varying inclination to the base of tangents to the curve, each measure relative efficiency at different portions of the line.

Each movement of tube length is of decreasing cooling value, and the decrement is considerable.

The efficiency under constant conditions of tubes of any length, or lineal sections of tubes, is proportional to the ordinate differences. The ordinate difference measures the work of a tube.

A glance reveals that the increased cooling effect attained by considerable lengthening of tubes, is not commensurate with the lengthening, especially so in nearly pure steam. For instance, take the "observed" section of the 6 ft. curve (*A*, Fig. 6) the temperature increment is 19° nearly. Assume the tube extended 6 ft. to the right—that is, doubled in length—the increment becomes 29·57°; therefore doubling the tube length has only increased the cooling effect some 50 per cent. Carry the comparison further, then the work of the first foot (3·97°). is nearly four times that of the fifteenth (1·022°). Obviously, in the limit in an indefinitely long tube, when the water within and the vapour without are at equilibrium of temperature, the value of 1 ft. of tube is zero.

With mixtures of air and steam—curve *B*, for instance—whilst the total work is less the change of ratio is also less. Compared with the last example the ratio is 2·38 : 1·05, as against 3·97 : 1·022. Probably this is due to the aggregation of air about the tube decreasing in the region of lower temperature differences.

When the presence of considerable quantities of air in steam was ignored, this effect rendered the use of tubes of considerable length not improper; but the

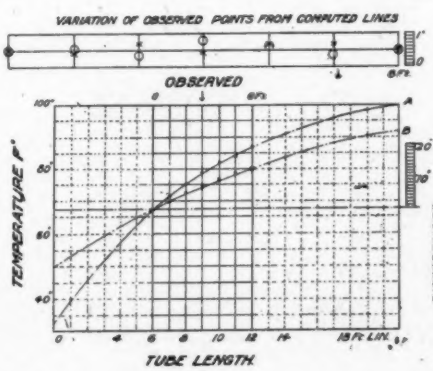


FIG. 6.

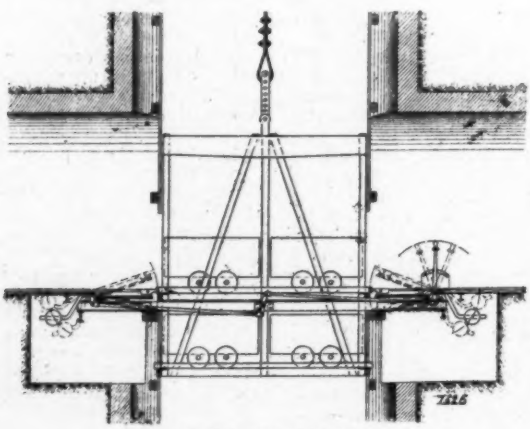
case is different with the purer steams that must now be dealt with. The old order changes, but the old practice persists.

The general deduction is that economy requires the use of relatively short tubes. There are, however, limits. If the greater mass of water required has to be raised from a considerable depth, or lifted to a considerable height (to a cooling-tower, for instance), the working cost will exceed interest charges on an arrangement that, by increased size, compensates for less theoretical efficiency. It is, again, a question of special designing.

(*To be concluded.*)

Substitute for Keps at the Pit Eye.

OWING to the trouble and loss of time involved in adjusting the cage exactly on the keps (more than half the cage accidents in the Dortmund district are, according to *Glückauf*, caused by the bumping of the cage on these stops), the Werne colliery has substituted the hinged platform shown in the drawing, at the pit eye. The free end of the platform rests on the rail track in the cage, whilst the other end is hinged on to the haulage track. The platform is raised and lowered by means of a lever, and is balanced by a counterpoise. It is also given a certain amount of play below the horizontal, so that the cage need not be adjusted with such great care as usual. The extreme outer end of the platform is hung on pivots, in such a manner that it always tends to assume a horizontal position, so that if, by accident, the platform has not been turned back, the descending cage merely depresses the swing extension and slips by without doing any damage. The device is also being adopted at several other Westphalian collieries, and is found to give increased security in winding, to prevent jamming of the cage, diminish the wear on the rope, save a good deal of the usual cost of repairs to the cage, and increase the winding capacity of the plant.



SUBSTITUTE FOR KEPS.

New Tramway Track Systems.

THE high cost involved in renewing tramway rails, and the disorganisation of traffic consequent thereon—for it must be remembered that the removing of the rail for replacement involves the taking up of the whole width of the roadway between the rails and fifteen inches on the outside of each rail—tends to the employment of rails much beyond the time when they should have been discarded, with consequent ill-effects to the motors, waste of motive power, and noisy running of the cars.

When a rail is worn beyond its proper life the flange of the wheel comes in contact with the bottom of the groove, thus setting up two contacts at different speeds. Slip due to the difference of the two circumferences therefore occurs, with its resultant heavy wear and tear. Further, when a new wheel is running on a worn rail, the weight of the car and drive is taken by the flange, with the result that the wheels are quickly spoiled and bad electric contact results owing to the accumulation of dust in the bottom of the grooves.

Although it is improbable that rails are allowed to wear to the extent indicated above, it should be noted that the proportion of the total weight of rail available for wear, before renewal becomes necessary, is a very small one. Of the grooved girder section rails rolled in one piece weighing from 92 to 108 lbs. per yard, now commonly employed, only 5·7 per cent. of the total weight can be thus taken out, when the whole rail has to be discarded, at a waste of 178 tons per mile of single track.

Besides the taking up and relaying of the roadway, other inconveniences are involved by the removal of a rail, such as the cutting away of fish-plate and sole-plate bolts, the

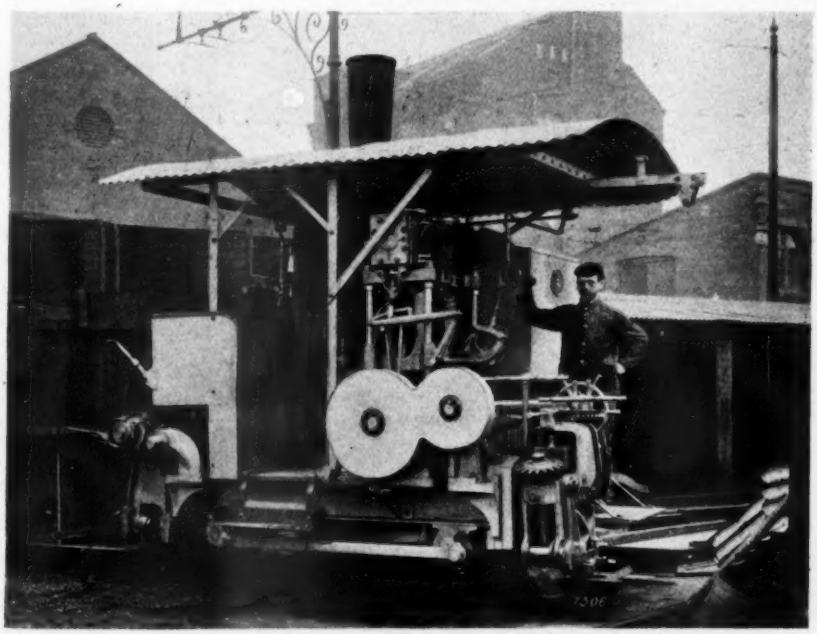


FIG. 1.—THE "ROMAPAC" RAIL-ROLLING MACHINE.

removal of sole plates, disconnecting and removal of tie bars, cutting and scrapping of bonds, etc. It is not, therefore, a surprising matter that attempts should have been made in the past to fit a removable head which could be replaced, when worn, at much less cost and inconvenience than could the whole rail.

None of these, however, appear to have reached a successful practical and commercial stage, but quite recently a system has been patented and introduced which, as far as it is possible to judge, seems to possess the necessary elements of success. The invention of Mr. E. Rhodes, of Leeds, it is known as the "Romapac" system, and includes the use of a compound rail and a

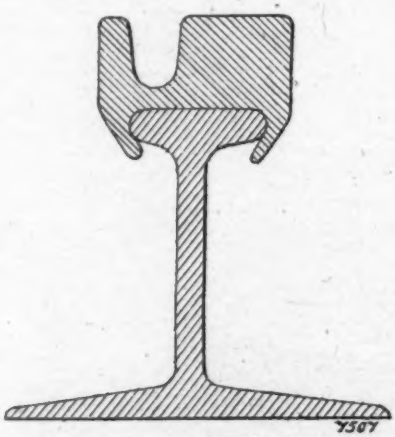


FIG. 2.—SECTION OF "ROMAPAC" RAIL.

machine for rolling and cold-welding the upper to the lower part, and for cutting them apart when worn out.

A section of the rail together with the renewable head is shown in Fig. 2, the machine employed being illustrated in Fig. 1. The latter consists of two essential parts, viz., the rolling and cutting machine (Fig. 3) for cutting and cold-welding the rail head and girder, and the breaking-off machine (Fig. 4). These machines are mounted on one bogie frame, together with the boiler and engines for driving them and propelling the complete apparatus.

In the construction of new lines the fixing machine alone is required. The lower girders being fixed in their place, and fished and tied to gauge, the top rail is now laid on to the under girder, and the machine travels along the rail, cold welding the two parts together. The speed at which this can be done is only limited by the speed at which the top rails can be laid in position.

In the repair of lines constructed on the new principle, the cutting-off machine travels along the rail making a deep cut in each flange of the upper section, which are then broken off by the breaking-off machine. The new top section is then placed in position so that its ends break joint with the joints in the girder, and the whole machine is run over it, the rolling-on apparatus being brought to bear so that it closes the two flanges of the cap. In this operation there is no interference with the permanent way beyond the removal of the setts immediately adjoining the line.

It is of the utmost importance that the adhesion between the two parts of the rail should be sufficient to prevent any displacement under actual conditions. To secure this, the head of the lower section has parallel grooves cut in each side running in the direction of its length; while the upper section has grooves cut inside the flanges in a direction at right angles to those of the longitudinal grooves of the girder. The following are the results of a test made by the Sheffield Testing Works, Ltd., to ascertain the pressure necessary to slide the top section off the bottom section of a combined rail 1 ft. long.

Weight per foot.	Length of Sliding Surface of Rail.	Pressure applied, in Tons. Movement of Top Section over the Bottom Section.		
Pounds. 38	Inches. 12·0	16·32 tons. ·02 ins.	18·21 tons. ·12 ins.	23·30 tons. ·26 ins

* The top section commenced to move with a pressure of 16·32 tons, and with a pressure of 18·21 tons the movement was ·12 ins. With a pressure of 23·30 tons the movement was ·26 ins., and on the test being continued the top section kept sliding off the bottom section without any further increase of pressure.

The above figures show that the force required to slide the top sections off the bottom sections of a 60 ft. length of track (2 rails) amounts to 2,796 tons, and to give a movement of $\frac{1}{50}$th of an inch, a force of 1958·4 tons is required. This is without taking into account the increased adhesion caused by the weight of the car.

Mr. J. H. Wicksteed, M.I.Mech.E., has, we understand, reported favourably on the resistance to bending, and Mr. J. B. Hamilton, General Manager of the Leeds City Tramways, finds, in a report, that an

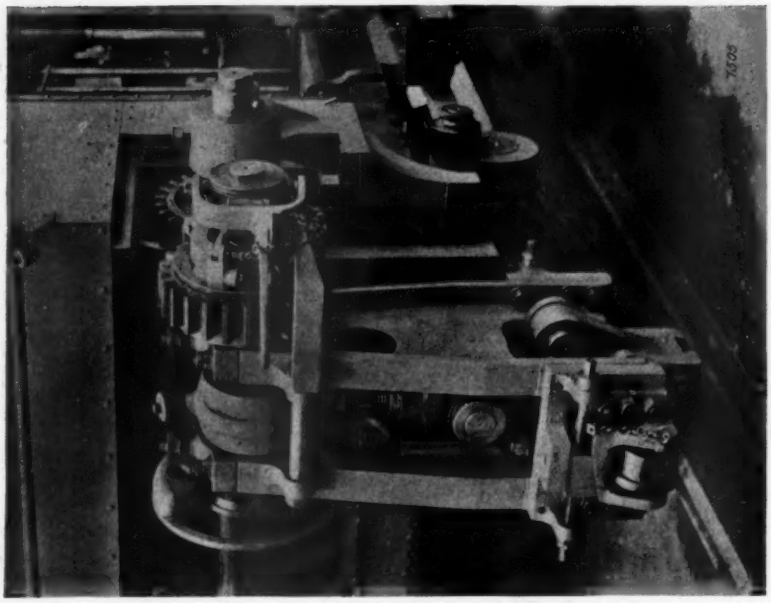


FIG. 4.—BREAKING-OFF MACHINE

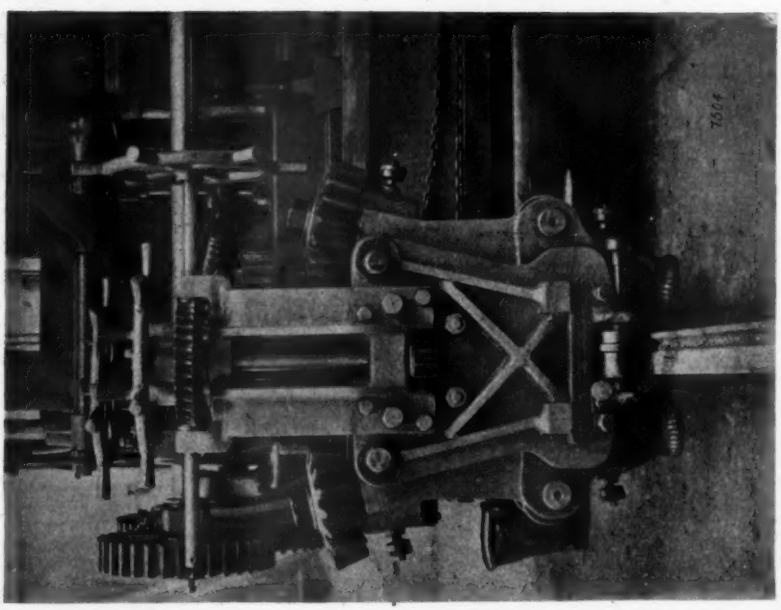


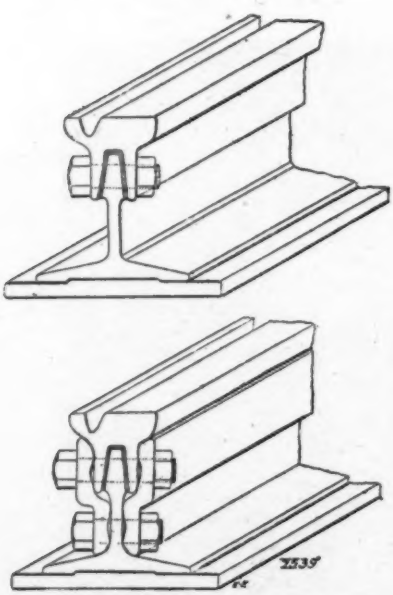
FIG. 3.—ROLLING AND CUTTING MACHINE.

economy equal to 53¼ per cent. can be effected in the maintenance of lines by the adoption of the "Romapac" system.

A length of a few hundred yards has been in use on the Leeds Corporation on this system since October last, which, we are informed, has given every satisfaction, and a further installation is to be carried out. So far as could be ascertained from an inspection of this length made by the writer, no sign of creeping or other displacement was apparent, and it is to be hoped that time will not develop any such difficulties.

It is hardly necessary to refer in detail to the machine itself, as the action can be clearly gathered from the illustrations. It will suffice to mention that the rollers of the rolling-on machine, which are driven through spindles and bevel gearing, can be applied to the rail head with varying degrees of pressure by means of a hand wheel.

For the cutting-off process, the rollers are removed and cutting tools substituted, which groove the sides of the flange. When these have been cut to the requisite depth the breaking-off machine (Fig. 4) is brought into operation, the jaws of which engage with the rail head in a rapid succession of grips, thus removing the flange as it travels along. The jaws are actuated through a toggle arrangement driven off the eccentric shown in the illustration.



FIGS. 5 AND 6.—TRAMWAY RAIL WITH RENEWABLE TREAD.

Another form of tramway rail with a renewable tread has recently been introduced by the Improved Patent Tramrail Company of Bootle, and is illustrated in Figs. 5 and 6. As recently described,* this new rail is built up in two sections, the bottom section consisting of bed-plate and web, the top section, or renewable portion, being similar in every respect to the surface of the rails now in use. As will be seen, a portion of the underside of the top section is flat for the purpose of resting on the top of the bottom section, and has a flange on each side for lapping over either side of the web. An asphalte or other approved packing is laid on the top of the web for arresting any irregularity arising in the rolling of the metals, and also forming a cushion to permit of slight relative movement between the sections and to prevent corrosion between the metals. The two sections when laid in position with the necessary packing between and bolted together (through flanges of the top section and the web of the bottom one), the distance between each bolt being 5 ft. from the rail complete. On each side of the rail opposite the bolts connecting the two portions together a hollow cast-iron sett is substituted for the existing stone sett for the purpose of indicating the position of the bolts, and thus facilitating the necessary access to same when the renewal of the top sections take place. A suitable sole or bed plate shaped to fit the underside of the rail is laid under each butt joint and under each bolt.

With the new rail the labour in connection with the roads is greatly reduced. It is the upper section only—the portion subject to wear and tear—which is required to be removed and renewed, the work of which can be rapidly executed by taking up the iron sett, removing the bolts, levering off the upper section, laying the new ones, and refixing the bolts and setts, the whole of which can be carried out with little interference with vehicular traffic. A feature not to be overlooked is that the renewed top section when laid on the lower one can be safely traversed by the cars or other vehicles before the bolts are actually fixed.

The points on which the construction may be criticised are the packing between the two sections and the reduced strength of the rail considered as a girder resulting therefrom.

* *The Electrical Engineer*

Locomotive and Railway Notes.

By CHAS. S. LAKE.

American Locomotive Tests.—The results of the tests carried out at the St. Louis Exhibition by the Pennsylvania Railroad Company, with several locomotives designed for working both passenger and goods traffic, were recently made public through the medium of a book running into 750 pages, and containing the whole of the data, conclusions, &c., obtained from the tests. Of the eight locomotives submitted to trial, four were for goods traffic and the remainder for passenger train working.

Two of the goods engines were simple; one was a 2-cylinder compound and one a 4-cylinder tandem compound. All the passenger locomotives were 4-cylinder balanced compounds, but on different systems. Foreign builders of locomotives were represented at the tests; one of the engines being a "de Glehn" 4-cylinder compound, and another the product of the Hannoverische Maschinenbau Company, also with four compound cylinders, and the boiler containing a superheater of the "Pielock" type. With the exception of these last two engines, the number tested were entirely of American build. There can be no questioning the value of the lessons taught by the results of these tests, and it is to be hoped that at some future time we may be permitted to know something of what has been achieved in this country on the testing plant at Swindon works, with various types of locomotives designed for and worked under conditions which actually apply on British railways. The summarised conclusions arrived at in America are as follows:—

Boiler Performance.

1. Contrary to a common assumption, the results show that when forced to maximum power, the large boilers delivered as much steam per unit area of heating surface as the small ones.

2. At maximum power, a majority of the boilers tested delivered 12 or more lbs. of steam per square foot of heating surface per hour; two delivered more than 14 lbs. and one, the second in point of size, delivered 16·3 lbs. These values, expressed in terms of boiler horse-power per square foot of heating surface, are 0·34, 0·40 respectively.

3. The two boilers holding the first and second place with respect to weight of steam delivered per square foot of heating surface, are those of passenger locomotives.

4. The quality of steam delivered by the boilers of locomotives under constant conditions of operation is high, varying somewhat with different locomotives and with changes in the amount of power developed, between the limits of 98·3 per cent. and 99 per cent.

5. The evaporative efficiency is generally maximum when the power delivered is least. Under conditions of maximum efficiency, most of the boilers tested evaporated between 10 and 12 lbs. of water per pound of dry coal. The efficiency falls as the rate of evaporation increases. When the power developed is greatest, its value commonly lies between limits of 6 and 8 lbs. of water per pound of dry coal.

6. The observed temperature of the fire-box under low rates of combustion lies between the limits of 1,400° Fahr., and 2,000° Fahr., depending apparently upon characteristics of the locomotive. As the rate of combustion is increased, the temperature slowly increases, maximum values generally lying between the limits of 2,100 and 2,300° Fahr.

7. The smoke-box temperature for all boilers, when worked at light power, is not far from 500° Fahr. As the power is increased, the temperature rises, the maximum value depending upon the extent to which the boiler is forced. For the locomotives tested, it lies in most cases between 600 and 700 degrees.

8. With reference to grate area, the results prove beyond question that the furnace losses due to excess air are not increased by increasing the area. In general, it appears that the boilers for which the ratio of grate surface to heating surface is largest are those of greatest capacity.

9. A brick arch in the fire-box results in some increase in furnace temperature and improves the combustion of the gases.

10. The loss of heat through imperfect combustion is in most cases small, except as represented by the discharge from the stack of solid particles of fuel.

11. Relatively large fire-box heating surface appears to give no advantage either with reference to capacity or efficiency. The fact seems to be that the tube heating surface is capable of absorbing such heat as may not be taken up by the fire-box.

12. The value of the "Serve" tube over the plain tube of the same outside diameter, either as a means for increasing capacity or efficiency, was not definitely determined.

13. The draught in the front end for any given rate of combustion as measured in inches of water, depends upon the proportions of the locomotive and the thickness and condition of the fire. Under light power, its value may not exceed an inch, but it increases rapidly as the power is increased. Representative maximum values derived from the tests lie between the limits of 5 in. and 8·8 in.

14. Insufficient openings in the ash-pan and the mechanism of the front end, especially the diaphragm, are shown by the tests to lead to the dissipation of considerable portions of the draught force.

The Engine.

15. The indicated horse-power of the modern simple freight locomotive tested, may be as great as 1,000 or 1,100; that of a modern compound passenger locomotive may exceed 1,600 horse-power.

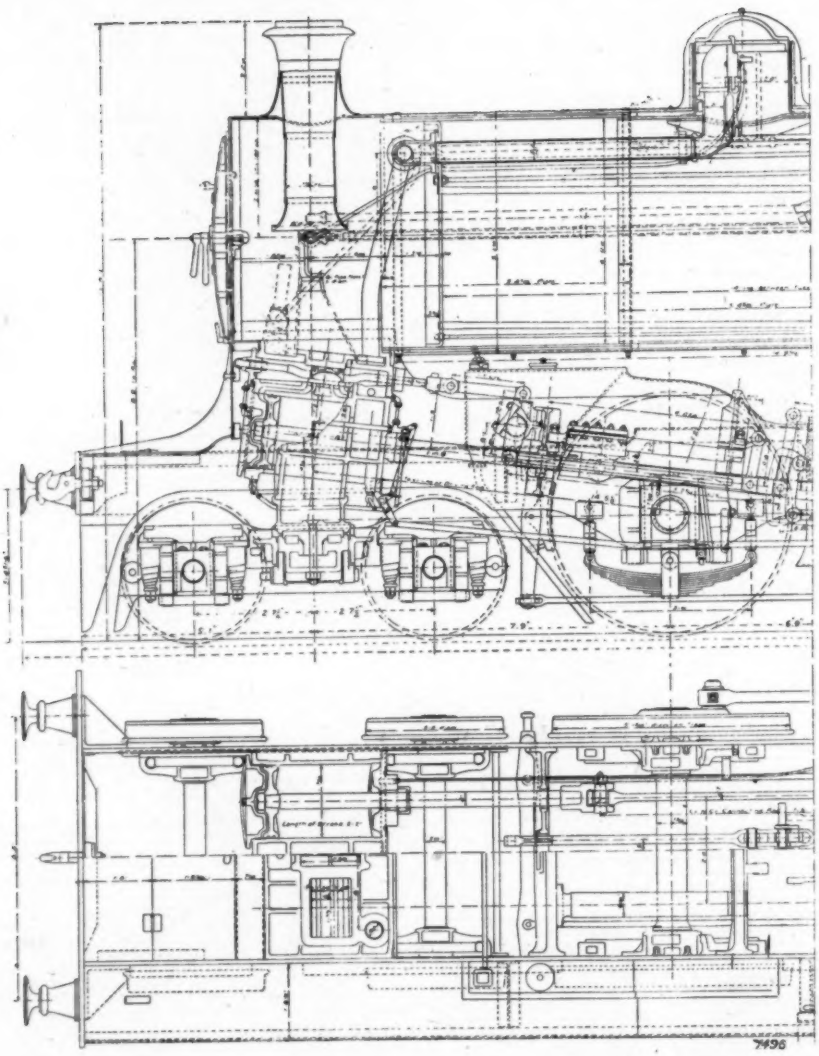
16. The maximum indicated horse-power per square foot of grate surface lies, for the freight locomotives, between the limits of 31·2 and 21·1; for the passenger locomotives, between the limits of 33·5 and 28·1.

17. The steam consumption per indicated horse-power hour necessarily depends upon the conditions of speed and cut-off. For the simple freight locomotives tested, the average minimum is 23·7. The consumption when developing maximum power is 23·8, and when under those conditions, which proved to be the least efficient, 29·0.

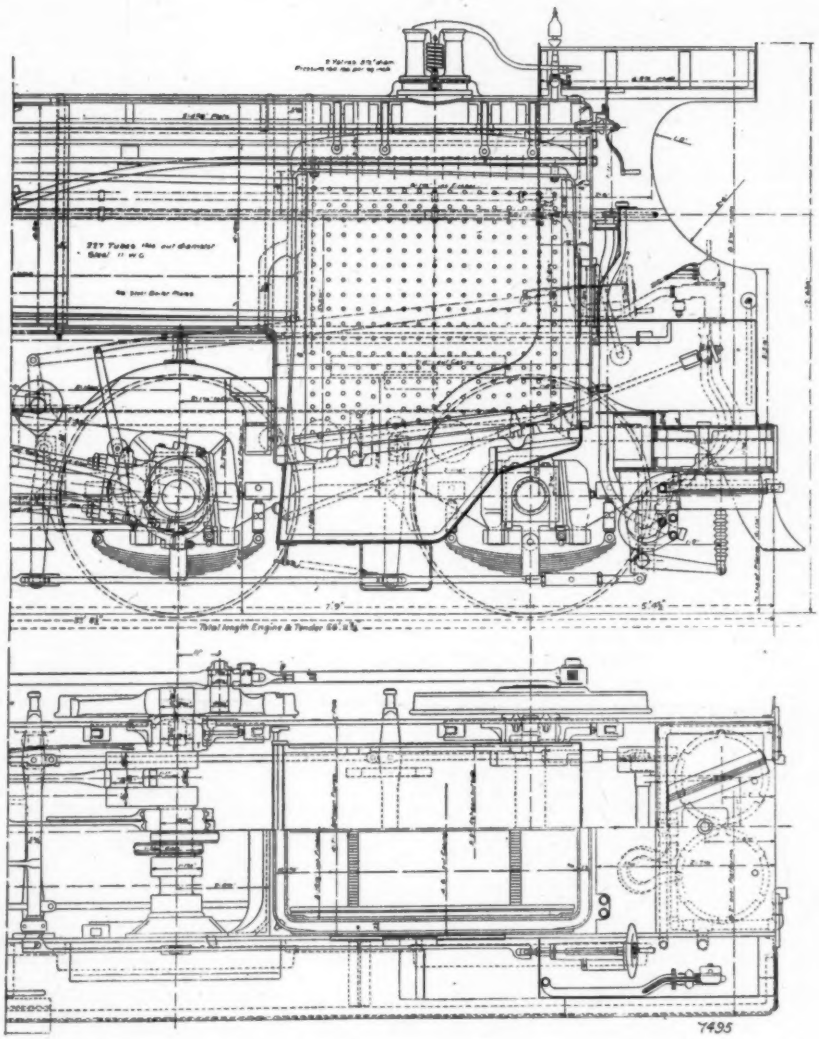
18. The compound locomotives tested, using saturated steam, consumed from 18·6 to 27 lbs. of steam per indicated horse-power hour. Aided by a superheater, the minimum consumption is reduced to 16·6 lbs. of superheated steam per hour.

19. In general, the steam consumption of simple locomotives decreases with increase of speed, while that of the compound locomotives increases. From this statement it appears that the relative advantages to be derived from the use of the compound diminish as the speed is increased.

20. Tests under a partially opened throttle show that when the degree of throttling is slight, the effect is not appreciable. When the degree of throttling is more pronounced, the performance is less satisfactory than when carrying the same load with a full throttle and a shorter cut-off.



EXPRESS GOODS LOCOMOTIVE, 4-6-0 TYPE,



GREAT SOUTHERN AND WESTERN RAILWAY.

THE LOCOMOTIVE AS A WHOLE.

21. The percentage of the cylinder power which appears as a stress in the draw-bar, diminishes with increase of speed. At 40 revolutions per minute, the maximum is 94 and the minimum 77; at 280 revolutions per minute, the maximum is 87 and the minimum 62.

22. The loss of power between the cylinder and draw-bar is greatly affected by the character of the lubricant. It appears from the tests that the substitution of grease for oil upon axles and crank pins increases the machine friction from 75 to 100 per cent.

23. The coal consumption per dynamometer horse-power hour for the simple freight locomotives tested, is, at low speeds, not less than 3·5 lbs. nor more than 4.5 lbs., the value varying with running conditions. At the highest speeds covered by the tests, the coal consumption for the simple locomotives increased to more than 5 lbs.

24. The coal consumption per dynamometer horse-power hour, for the compound freight locomotives tested is, for low speeds, between 2·0 and 3·7 lbs. Results at higher speeds were obtained only from a 2-cylinder compound, the efficiency of which under all conditions is shown to be very high. The coal consumption per dynamometer horse-power hour for this locomotive at the higher speeds increases from 3·2 to 3·6 lbs.

25. The coal consumption per dynamometer horse-power hour, for the four compound passenger locomotives tested, varies from 2·2 to more than 5 lbs. per hour, depending upon the running conditions. In the case of all of these locomotives, the consumption increases rapidly as the speed is increased.

26. A comparison of the performance of the compound freight locomotives with that of the simple freight locomotives is very favourable to the compounds. For a given amount of power at the draw-bar, the poorest compound shows a saving in coal over the best simple which will average above 10 per cent., while the best compound shows a saving over the poorest simple which is not far from 40 per cent. It should be remembered, however, that the conditions of the tests, which provide for the continuous operation of the locomotives at constant speed and load throughout the period covered by the observations, are all favourable to the compound.

27. It is a fact of more than ordinary significance that a steam locomotive is capable of delivering a horse-power at the draw-bar upon the consumption of but a trifle more than 2 lbs. of coal per hour. This fact gives the locomotive high rank as a steam power plant.

28. It is worthy of mention that the coal consumption per horse-power hour developed at the draw-bar by the different locomotives tested presents marked differences. Some of these are easily explained from a consideration of the characteristics of the locomotives involved. Where the data is not sufficient to permit the assignment of a definite cause, there can be no doubt but that an extension of the study already made will serve to reveal it.

Locomotives for Fast Goods Traffic: Great Southern and Western Railway of Ireland.—Reference was made to these engines in last month's Notes, when a photographic reproduction of one of the series appeared, together with a description and the leading dimensions of the type. The drawings clearly show the general arrangement of the design, and it will be seen that, although the intermediate pair of coupled wheels are the drivers, ample clearance between the connecting rods and the leading coupled axle is provided by placing the cylinders well up above the bogie and inclining them at 1 in 8. There is no real objection to this plan, especially where the coupled wheels are of relatively small diameter, as in this case; but it has not, as stated last month, hitherto been adopted for the 4-6-0 type of engine in Great Britain. Excellent all-round results are being obtained with these new locomotives, of which six, all built at the Great Southern and Western Railway Company's Works, Inchicore, have now been placed in service.

New Coaching Stock: Caledonian Railway.—Those who have frequent occasion to travel upon the Caledonian Railway cannot but be disposed to regard that line, not only as the premier one in Scotland, but also as one of the best and most energetically managed among British railways.

The locomotives and passenger rolling stock used on the majority of the services are of the most modern and well-designed description, and the general equipment of the line is of a high order. The rebuilding on an entirely new scheme of the Central Station, Glasgow—a work now nearing completion—will give the company one of the finest and best designed terminal stations in this country, whilst in whatever direction one may look the same spirit of enterprise is met with in the conduct of the line. The new type of carriage used on the express service between Glasgow and Edinburgh, the first of which were put into running last year, is now being built in some numbers at St. Rollox Works.

A few complete trains have already been turned out of the shops, and others are in course of construction, for use on the coast services to and from Glasgow, Wemyss Bay, Ardrossan, Gourock, &c. Every care has been taken in designing these coaches to provide the maximum of comfort for first and third-class passengers alike without unduly adding to the total weight to be hauled, and the writer having, by the courtesy of the designer, Mr. J. F. McIntosh, locomotive, carriage, and wagon superintendent of the Caledonian Railway, inspected the cars at St. Rollox, both during construction and after completion, can find nothing but unqualified praise for them.

Although the new carriages are intended mainly for use on comparatively short journeys, they are equal in every essential, as regards the appointments, to those built for the famous "Grampian" corridor express, introduced last year on the Glasgow and Edinburgh to Perth and Aberdeen services, the main difference between the "Grampian" coaches and those used on other sections being that the former have corridors, whilst the latter are of the non-corridor type. In the first-class vehicles there are nine compartments, with seats for eight passengers in each, the total length between the dividing partitions being 7 ft. 1¼ in., and the width inside compartment 8 ft. 4½ in. The length of the coach over mouldings is 65 ft. 0¾ in., and the width, also measured over mouldings, 9 ft., the height from rail level to top of roof being 12 ft. 1 in. Of the nine compartments four are for smokers and five for non-smokers, the former being arranged two at each end of the car. The seats are upholstered with brown tapestry moquette with silk vellum lace trimming, the floors being covered with cashmere rugs to match. The ceilings are finished in white

lincrusta with gold decoration, and the electroliers, racks, and blind covers are of gilt. The third-class carriages, which are 68 ft. long over body and 71 ft. 6 in. over buffers, have eleven compartments, and the seats are upholstered in figured French carpet material of handsome design, linoleum of a pattern selected to harmonise with the general colour scheme, being used to cover the floors. The woodwork in these carriages is mostly in mahogany with gold relief. Each coach runs upon two six-wheeled bogie trucks fitted with a new arrangement of springs, comprising three different types to counteract both the vertical and lateral oscillations, there being in addition a continuous cushion of indiarubber between the car body and the frame, whilst patent hair felt is packed below the floors and in the sides and roofs.

The trains are lighted throughout on Stone's system, and the equipment includes steam heating, the chain system of communication and ventilating arrangements of the most complete kind. Both the Caledonian Railway Company and the travelling public are to be congratulated on the introduction of the new trains.

August von Borries. — The death which occurred a week or two ago of Professor Von Borries, removed one of the best-known from among those who have made the improvement of the steam locomotive one of the main objects of their lives. Professor Von Borries was from the first a great believer in the possibilities of locomotive compounding, and he was directly responsible for the first introduction of that class of engine on the railways of Prussia. This was in 1880 when, at the age of twenty-eight, he was asked to prepare for the Hanover State Railway, a design of locomotive having two compound cylinders and fitted with a starting valve of the "Von Borries" type. Two engines were built by the firm of F. Schichau of Elbing, and they gave every satisfaction under the conditions prevailing at that time. As a result of some fourteen years of continual experimenting, Von Borries attained such a measure of success with locomotive compounding that the Government decreed, in 1895, that in future the compound system was to be used for all express locomotives, and for all goods locomotives making long runs, on the Prussian State Railways.

Subsequently he turned his attention to the 4-cylinder compound locomotive, and in 1890 invented a type of valve-motion specially designed to give a simple means of equally dividing the work between the high and low pressure cylinders.

The latest type of locomotive built on the "Von Borries" system for the Prussian State Railways, has been widely illustrated and described in the engineering Press. It is of the "Atlantic" (4-4-2) type, with the four cylinders arranged in line at the bogie centre: two, the high pressure, inside the frames and the low-pressure outside, all four cylinders driving the first coupled axle. The four valves are operated by two sets of gear, the pair of valves on each side of the engine being controlled by a single link receiving motion from one eccentric, but the stem of each valve is coupled to an advance lever which receives its motion from the cross-head of the corresponding piston.

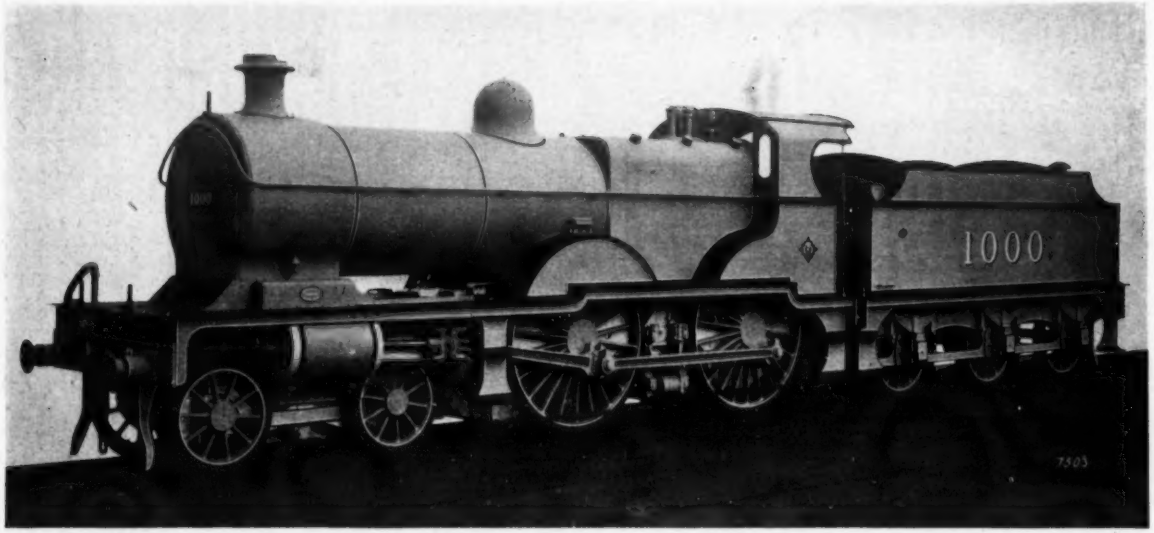
The boilers of these locomotives contain a superheater of the "Pielock" type. One of the engines took part in the famous Marienfelde-Zossen speed trials where it rendered a very creditable account of itself, and a similar locomotive was sent to the St. Louis Exhibition. Professor Von Borries was at one time associated, as co-patentee, with Mr. T. W. Worsdell, when the latter occupied the position of Locomotive Superintendent to the North Eastern Railway. Several engines of the 2-cylinder compound type bearing their joint names, and also that of Mr. Lapage, were built both for passenger and goods service on the line mentioned during the period covered by the years 1889-1894, and some of the goods locomotives, if not some of the tank engines, still remain in use, unless they have recently been broken up.

Professor Von Borries died at the age of fifty-four years, having only three years or so previously, viz., in 1902, been given the rank of Privy Councillor, and appointed Professor of the Science of Transportation at Berlin University.

Japanese Railways.—A Bill, having as its object the nationalisation of the Japanese Railways, has recently been carried without amendment in the Parliament of that country. The entire cost of the purchase of the railways is estimated at 500,000,000 yen, and the Minister of Finance expresses confidence that the purchase can be effected in five years time without disturbing the market.

New Compounds for the Midland. —The writer is indebted to Mr. R. M. Deeley, M.Inst.C.E., locomotive superintendent of the Midland Railway Company for the accompanying photograph of one of the new 3-cylinder compound express passenger locomotives recently completed at Derby Works. These are similar in general arrangement to the other compounds already at work on the Midland Railway, but they constitute an advance upon their predecessors in respect of certain details of construction, and some of the dimensions are also different. Further attention will be called to this matter in next month's Notes, when sectional drawings and a full list of dimensions will also appear. The engines are compounded on the system devised by Mr. W. M. Smith, of Gateshead, and are being placed in service on some of the heaviest and fastest express passenger traffic on the Midland main line.

New Coaching Stock: Great Central Railway.—When the new train services inaugurated by the Great Central Railway



3-CYLINDER, COMPOUND EXPRESS LOCOMOTIVE, MIDLAND RAILWAY.

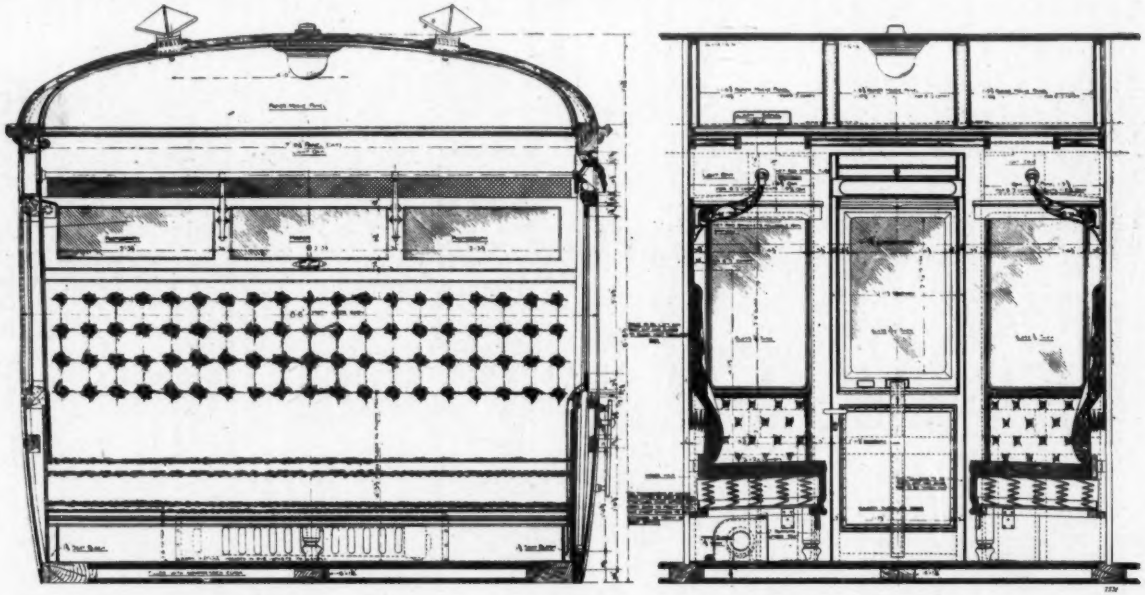
between Marylebone, Aylesbury (*via* Metropolitan Railway) and Woodford came into operation on March 1st, several new trains which had been built for this and also for service over the new line, *via* Northolt, High Wycombe, and Princes Risboro', were brought into use for the first time. The carriages of which the trains are comprised may be described as second to none found on any British railway; indeed, for the class of traffic for which they were specially designed, it is safe to go further and state that they are unequalled on any other line. A prominent railway journal has described them as the "last word" in railway carriage construction for suburban traffic, and with this opinion the writer, as a daily passenger by the trains over a considerable distance, is heartily in agreement.

The first-class carriages are finished in walnut with sycamore panels, the roofs are lincrusta picked out in gold, and the seats and backs are upholstered in green cloth. The third-class carriages are finished in polished oak with roofs of *papier mâché* painted and lined, the seats and backs being upholstered in red figured moquette. The trains are lighted by electricity, and heated by steam, there being controlling handles in each compartment. An excellent system of ventilation is also provided.

The principal dimensions are as follows:—Length over body, 50 ft.; width over body, 8 ft. 6 in.; length over headstocks, 49 ft. 4 in.; centres of bogies, 33 ft. 6 in.; wheelbase of bogies, 8 ft.; length of compartments (first-class), 6 ft. 11¾ in., (third-class), 6 ft. 1⅛ in.: total height, 12 ft., 1 in.; total length over buffers, 53 ft. 1½ in.; number of passengers, 42.

Large Locomotive Boilers.—The adjourned discussion on Mr. G. J. Churchward's paper on "Large Locomotive Boilers," at the meeting of the Institution of Mechanical Engineers, held in March last, proved as interesting as the paper itself had been, although much greater value would attach to all these discussions if only the time at the disposal of the meeting could be extended so that the speakers might be afforded a better opportunity for expressing their views at greater length. At the opening of the discussion at the February meeting, after the reading of the paper had been concluded by Mr. Churchward, Mr. George Hughes, of the Lancashire and Yorkshire Railway, expounded his views on locomotive boiler design in a speech, which was at once interesting and instructive; and he was followed by other speakers, including Mr. James Stirling, late locomotive superintendent, South Eastern Railway, who described himself as being somewhat old-fashioned and not altogether in agreement with locomotive engineers on the big boiler question, and Mr. King, of Swindon, the general trend of the various speakers' remarks being towards the subject of locomotive fire-boxes.

Mr. Druitt Halpin, at the March meeting, showed on the screen a number of slides illustrating the methods adopted by Continental engineers in their endeavours to dispense altogether with the locomotive fire-box. Another unusual feature of construction, the

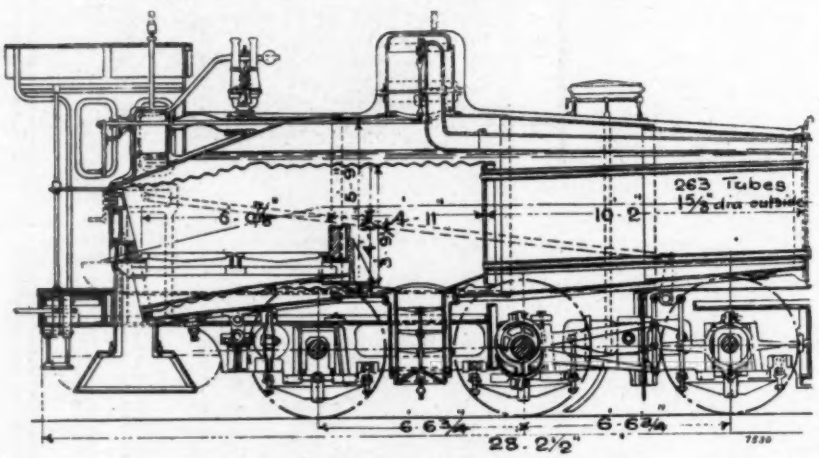


NEW BOGIE CARRIAGE (SUBURBAN STOCK) GREAT CENTRAL RAILWAY: DETAILS OF THIRD-CLASS CARRIAGE.

corrugated fire-box, was dwelt upon by Mr. Halpin, who, for illustration, took as his example the type of boiler invented by Herr Lenz, of the Hohenzollen Locomotive Works, a number of years ago. A sectional drawing of one of these boilers is reproduced herewith, and, as will be seen, the outer shell is partly straight and partly inclined; in other words, it is formed of two truncated cones, with a cylindrical portion between them. The corrugated flue or fire-box is curved, and slopes downwards towards the rear end. By this arrangement the ends of the boiler are smaller than the intermediate portion, thus providing the greatest steam space at about the middle of the length of the boiler. The tubes are sufficient to support the tube plates, and no further stays are required. The fire-box is divided into two parts by a semi-circular fire bridge, and the gases from the fuel are mixed at this bridge with hot air and consumed in the combustion chamber beyond. A number of these boilers were made, but after one had exploded, with disastrous results, the others were withdrawn from service. Mr. Halpin next spoke of his thermal storage system for locomotives, particulars of which have been given at various times in the ENGINEERING REVIEW, and he stated incidentally that over 2,000 engines were at work in Russia fitted with the arrangement.

The next speaker, Mr. Wright, of Swindon, advocated in a few brief sentences the use of water-softening plant, stating that the cause of tube and stay trouble might frequently be found in the employment of a wholly unsuitable water. After some remarks by Mr. Vaughan Pendred on the subject of leaking tubes, Mr. C. J. Bowen-Cooke, of the London and North Western Railway, observed that under the new *régime* at Crewe they had got over most of their boiler troubles by using a very simple design, reducing the pressure from 200 lbs. to 175 lbs., and attending closely to the nature of the water they evaporated. He urged the importance of keeping a very strict watch upon those who were given charge of the boiler. Unless the most careful supervision was exercised in regard to the washing out and inspection of the boilers, and unless everything was done to avoid the accumulation of fast dirt, trouble would be certain to arise.

Mr. W. H. Maw, who prefaced his remarks by stating that it was almost impossible to go wrong in the outline of the shell of a loco-



THE "LENZ" STAYLESS LOCOMOTIVE BOILER.

motive boiler, went on to say that he was glad to learn that Mr. Churchward was pleased with the "Belpaire" type of fire-box. He had himself designed a number of boilers of varying sizes with this pattern of box, and had obtained very satisfactory results. One or two small points in connection with the "Belpaire" box required attention, however, among them being the relation between the radii of the top corners of the inside fire-box and outside shell. The accompanying sketches illustrate the trend of Mr. Maw's observations on this point, which were to the effect that the centre *a* of the curve for the outer corner should be on the same vertical line as the centre *b* for the inside fire-box. If it were not there would be a difference in the boxes, and if the radius of the outer shell was less than shown in the sketch, and there was consequently a wider flat surface at the top, there would be a

tendency for the top to arch upwards when the boiler was at work, pulling the fire-box crown up with it. If, on the other hand, the radius of the outer shell was made too large, the flat surface of the shell would be narrower than that of the fire-box, and the two surfaces would be pulled down under pressure. The speaker then went on to remark upon other features of boiler and fire-box design, urging the necessity of using a wide water space in front of the fire-box under the boiler barrel. One advantage of so doing was that the vertical seams of rivets of the inside fire-box and fire-box shell could be kept well clear of each other (as shown in Fig. 1), whereas with a narrow front space it often happened that these lines of rivets came opposite each other (as shown in sketch, Fig. 2), where a space of only $\frac{5}{8}$ in. was left between the rivet heads, the water having to flow through this narrow space to the sides of a large fire-box. The consequence of this was that the whole of the lower stays of the boiler, which was of the locomotive type installed on board of a ship, leaked very quickly, and the plates became damaged.

Mr. Lawford H. Fry, of the Baldwin Locomotive Works, Philadelphia, called attention to what was being done in America with boilers of large size. He urged the necessity for using purified water, and followed up this by remarking upon features in the design of fire-boxes, the materials used in their construction, and kindred matters.

In replying to the discussion, Mr. Churchward laid special stress upon the advantages of water softening. The secret of success with the high pressure and high capacity locomotive boilers of modern times lay in that direction. Pressures and dimensions were increasing, and he believed it would be impracticable to maintain them unless the water problem were attacked. Generally speaking, the softening of water greatly moderated tube troubles, so that the difficulties with pressures of 200 lbs. to 225 lbs. were not proportionately greater than those which occurred when hard water was used at lower pressures. Increasing the size of the boilers so as to obtain heat storage in the boilers themselves was a good plan, and, although Mr. Churchward did not say so, it may be inferred that he viewed this principle as being superior to thermal storage in a separate chamber.

The principle of doing away with the fire-box was particularly interesting to him, because he had long been scheming to this end, but his

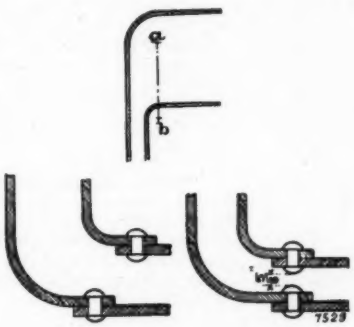


FIG. 1. FIG 2.

plans had invariably resulted in just a collection of tubes running in all directions, and when he looked at the number of joints and other connections he concluded that there might be as many opportunities for trouble in doing away with the fire-box as there were in maintaining it. Going to the subject of feeding water into the steam space, the speaker said that Mr. King and himself had done a great deal at Swindon in their efforts to devise some practical means of feeding the water through the steam. He could see no reasonable objection to doing this; it would certainly prevent those local differences of temperature which were undoubtedly the cause of a good deal of boiler trouble. He should continue experiment in this direction until some success was obtained.

Mr. Churchward wished he was in a position to do as they were doing on the London and North Western Railway in reducing pressures. He could quite realise that with the simpler type of boiler they experienced less trouble on the London and North Western Railway, as Mr. Bowen Cooke had stated. Mr. Maw's remarks upon the curves in the plates of "Belpaire" boilers were important, and in making them the gentleman named had touched upon the main difficulty with a "Belpaire" fire-box of balancing in all directions. After some further remarks upon the methods employed on the Great Western Railway for staying fire-box crowns, Mr. Churchward concluded by thanking the meeting for the attention they had given him.

Automobile Engineering Notes.

By ROBERT E. PHILLIPS, M.I.Mech.E., A.M.Inst.C.E.

Cordingley's Motor Exhibition.—This, the last of the annual motor shows in point of date but first in point of age—being the eleventh of the series—although not recognised by the Society of Motor Manufacturers and Traders—the promoters of the annual exhibition at Olympia—proved to be of exceptional interest, by reason of the large number of commercial vehicles exhibited. No more convincing evidence of the development of this side of the motor-car industry could be forthcoming than the large number of firms who have embarked on the manufacture of this class of motor road vehicle, and it is interesting to note that a large proportion of these are well-known firms in the engineering world. Amongst the newcomers may be mentioned: Messrs. Beyer, Peacock & Co., Ltd., of Manchester, of locomotive fame, whose exhibit consisted of a steam lorry, one of the many interesting features of which is the boiler—made under Hoy's Patent—which, although vertical in shape, embodies all the essential advantages of the locomotive type; Messrs. Chas. Burrell & Sons, of Thetford, who exhibited a tractor following on reduced lines the well-known traction engine built by this firm; Messrs. Hindley & Sons, of Bourton, who showed a 5-ton steam wagon, with a van body built for Messrs. Pickfords, Ltd.; Messrs. Allchin, Ltd., of Northampton, who showed a five-ton steam wagon with locomotive type of boiler—a feature of this wagon is the enclosing of the side driving chains and the gear wheels in cases, fitted with readily detachable covers; Messrs. Alley and Maclellan, Ltd., of Glasgow, who exhibited a six-ton steam wagon, which has so many features of interest that we shall refer to it at length at a later date, when we can illustrate some of its most novel features; Messrs. Wallis and Stevens, Ltd., of Basingstoke, whose exhibit consisted of a five-ton lorry, which only differs from the tractor made by this firm in that the wheels are spread to enable a platform to be carried, and that the transmission is entirely by gearing: Messrs. Barford and Perkins, who exhibited a water ballast roller propelled by an 8 h.-p. Simms petrol motor. Several new firms exhibited their productions for the first time. Amongst them we notice: Messrs. The Critchley-Norris Motor Co., of Bamber Bridge, near Preston, who showed a chassis suitable for an omnibus, which may justly claim to be the most up-to-date chassis for this particular class of work yet produced. The design—for which Mr. J. S. Critchley is responsible—embodies so many novel features that we defer dealing with it at length until we can illustrate it. We note, however, that the engine, which is rated at 35-40 h.-p., is built by Messrs. Crossley Bros., Ltd., whose petrol engines in no way belie the established reputation of this firm for gas engines. Messrs. The Industrial Motor Co. of Windsor, showed a one-ton van, driven by a petrol engine rated at 14 h.-p. The Lancashire Steam Motor Co., Ltd., of Leyland, exhibited for the first time their new 35-40 h.-p. bus chassis, which was found on close inspection to be a substantial job, designed to meet the excessive strains this class of vehicle is so subjected to. The radiator is placed inside the flat part of the frame so as to be protected thereby. The transmission is by a propeller shaft and live axle, but the latter differs from the usual construction, inasmuch as the differential is not carried in the live axle, but is mounted on an intermediate shaft located in front of the live axle and connected thereto by gearing, which reduces the transmission about a third. The wheels are of the composite type, having tubular spokes, and the system of suspension adopted embodies a transverse spring at the back. The Improved Electric Traction Co., Ltd., showed an electric delivery van which they are introducing on the contract system, a fixed inclusive charge being made per week or for longer periods. The vans are constructed to carry loads up to one ton at a speed of from 12 to 16 miles per hour. Any type of body can be fitted to suit the user.

The pleasure vehicle section of the exhibition, which was conspicuous by the absence of all the leading makers who exhibited at the Olympia Show, was remarkable, in that it included no less than three more new Italian firms. The exhibits of these firms, named respectively the "Isotta Fraschini," the "Premier-Marchand," and the "Milano," are all conspicuous for their simplicity and the absence of that conglomeration of extraneous fittings that so many manufacturers

seem to delight in decorating their chassis with. A perfect exemplification of the existing state of the industry in this country in component parts is the Chassis Construction Company, of Taunton, a company formed to construct chassis embodying principally component parts manufactured by French firms.

Air-Cooling *v.* Water-Cooling.—It has been left to an American to demonstrate the possibility of running a heavy vehicle with an air-cooled petrol motor. The Knox Co., of Springfield, Mass., has placed on the market an air-cooled motor for commercial vehicles, and the measure of success they have achieved is best gauged by the fact that a light lorry, with a 16-20 h.-p. air-cooled engine constructed on their system, ran as a baggage wagon throughout the Glidden touring trials, a distance of over 20,000 miles, without any trouble. The patent system employed by this company is to form the radiating surface of the cylinders in the form of a series of corrugated pins, and the fact that it is efficient for engines of large power is testified by the fact that they are built up to 40 h.-p.

Steam *v.* Petrol.—In a paper on "Motor Engineering" read before the Automobile and Cycle Engineers' Institute, Lieut.-Col. Crompton, C.B., made a comparison between the cost of running a steam and a petrol car, basing his figures on the assumption that a car to carry five or six people and luggage, and able to climb hills at a fair speed, would cost £600 if the motive power was steam, and £900 if it was petrol. Taking the miles travelled at 5,000 per annum, he gave the following figures, expenses common to both, such as rent of garage, wages of driver, and insurance, &c., being omitted:—

	Steam.	Petrol.
Steam car costing £600 depreciates 15 per cent.	90 0 0	—
Petrol car, same size, costing £900, depreciates 15 per cent.	—	135 0 0
Fuel for 5,000 miles:—		
Steam car at 12 miles per gallon of paraffin or benzoline at 7½d.	13 0 0	—
Petrol car at 20 miles per gallon of petrol at 10d.	—	10 10 0
Tyre repairs:—		
Steam car, complete set of tyres two-thirds worn out	37 0 0	—
Petrol car, complete set of tyres, fully worn out	—	45 0 0
Spares and ordinary repairs	38 0 0	80 0 0
	£178 0 0	£270 10 0

which shows a balance in favour of the steam car of £92 per annum. We think that not a few will be found to disagree both with the relative cost of the two types of car, but also with the relative cost of repairs, &c.

Armoured Motor Cars.—It may safely be taken for granted that in the next war in a civilized country—we use the word in the sense of having properly constructed roads—motor-cars will take an important part, not only for the rapid transport of troops and guns from one position to another, but also for use in the fighting line. The manufacturers of both France and Germany are building cars for war purposes. In Germany an armoured scouting car has been designed and built by Herr Emil Schmidt, of Berlin, for the War office. The outlines of the vehicle are those of the modern touring car, with the exception that all projections are as far as possible avoided. The body part is heavily armoured with steel plates, and is so constructed as to entirely cover the driver, sight-holes being provided. The plates used are 2·36 in. thick, and are capable of resisting bullets from the modern rifle. The back part of the body is provided with four seats. The armament consists of two quick-firing Mauser guns, each capable of firing 200 rounds per minute. One of these is placed in the forepart of the vehicle, with its barrel projecting through the front armour plate, and the other is mounted in the rear part of the vehicle, and is arranged to swivel in any direction. Although the first weapon can only fire in one direction, the horizontal angle through which it can be moved is considerable. Telescopes mounted on immovable stands are provided, and the illumination is by means of small electric lamps. In France, the firm of Charron, Girardot and Voigt has recently completed a fighting automobile for the Russian Government, which, it is alleged, is the first of a large number ordered by the Autocrat of the North, the delivery of which will extend over the next three years. The chassis is of the ordinary 30 h.-p. type, with stronger springs and axles and disc wheels. All the wheels are interchangeable, and two spare ones are carried, so that it would seem as if these were considered the most vulnerable parts. The tyres are pneumatic, the inner tubes being treated with a special solution, which it is stated will enable the car to be run for ten to twenty minutes after the tyres are punctured or damaged by bullets. The front seat for the driver and his mechanic is entirely enclosed with light armour plate, sight-holes being provided to enable the driver to see where he is going. Means are provided for starting the engine from the driver's seat. The rear part of the vehicle

is a miniature fort, in the turret of which is a quick-firing Hotchkiss gun, the capacity of which is 500 rounds per minute and the range 2,500 yards. The steel used in the armament of this car is so tough that bullets fired from a Lebel rifle at a range of from 100 to 150 yards cause but a slight indentation of the plates. At 50 yards the bullets remain in the plate, and they only pass completely through at a range of 20 yards. The petrol tanks, which have a capacity of nearly fifty gallons, are located behind the front seat. With five persons on board, all the tanks filled, and with the maximum quantity of ammunition, the vehicle weighs close on three tons, and can attain a speed of twenty-five miles an hour on an average road, and from eight to ten miles an hour across country, for which work it was specially designed. To enable ditches to be crossed, two metal rails—of trough-shaped section—are carried for use as temporary bridges. It is said that the cost of these vehicles is £3,200 each. It must not be supposed that either the French or the Germans are showing the lead in this direction, for, as far back as 1900, Mr. Frederick R. Simms built and demonstrated the practicability of an armoured petrol vehicle carrying a quick-firing gun.

Electrical Notes.

By ANDREW STEWART, A.M.I.E.E.

Electric Power in Mining.—The economics of electric power in mining received an unusual share of attention during the last few weeks, and round the subject of electric winding has raged a controversy, such as has not disturbed the minds of engineers for some time past. The earliest indication of any interest in the subject was a paper read last January to the Manchester Section of the Institution of Electrical Engineers by Mr. W. C. Mountain, and which was subsequently discussed at no less than three meetings of the parent institution in London, though in the meantime Mr. Gerald Hooghwinkel carried war into the enemy's camp by reading a paper before the Newcastle Section of the Institution on March 19th, directly contradicting Mr. Mountain's conclusions. Unlike most prophets, Mr. Mountain gets a good deal of honour in his own country, and there was no lack of support for his arguments, though naturally Mr. Hooghwinkel got a good deal of support from that very large section of the profession who take it for granted that anything electrically driven must be economical.

Mr. Mountain began by showing that the steam winding cost in existing collieries varied from 5*s.* 3*d.* to 16*s.* 11*d.* per 100 tons wound from the pit. There were two cases, one higher and one lower, than the limiting figures given above, but as these were plainly due to abnormal conditions no notice will be taken of them, as the high costs in most mines were due to the use of old prime movers, such as low pressure, simple, non-condensing engines. Mr. Mountain, in addition to the actual figures for modern plant, obtained from Messrs. Fraser & Chalmers and Messrs. Markham & Co., some figures as to the cost with modern high pressure compound winding engines; both these firms being in close agreement as to costs, the first named giving 6*s.* 4*d.* per 100 tons when winding 1,000 tons per day from a mine 500 yards deep, and 6*s.* 6½*d.* when winding 2,000 tons per day from a mine 700 yards deep, including, of course, capital charges; the winding period being ten hours per day in each case. Mr. Mountain's own figures, based on the results of similar modern steam winding engines, put the cost per 100 tons at six to seven shillings.

Proceeding to enlarge upon the influence of the cost of energy purchased from an outside source, and that from a private generating plant at the mine, Mr. Mountain showed that the price which any colliery could afford to pay for electrical energy for winding purposes varied from ·35 to ·18 pence per unit, depending upon the depth of the mine and the daily output; these prices, it should be noted, are the highest prices which collieries could pay in order that the cost of winding by electricity should not exceed the worst example of steam winding, viz., 16*s.* 11*d.* per 100 tons wound. With a view to proving that the cost of winding by electricity was high, Mr. Mountain cited the Grand Hornu Mine in Belgium, which, with an output of 1,400 tons per day from a depth of 766 yds, winds by electricity at a cost of 19*s.* 7½*d.* per 100 tons (including interest and depreciation on plant). Finally, Mr. Mountain gives a table setting out in detail the cost per 100 tons wound by electricity from mines varying in depth and output, that for a mine raising 1,000 tons per 8-hour day from a depth of 500 yards being 13*s.* 9½*d.*, and raising 2,000 tons from a depth of 700 yards, 12*s.* 5*d.*

Mr. Gerald Hooghwinkel's paper was,

generally speaking, a reply to that of Mr. Mountain, no attempt being made to do more than show that electric winding was chiefly remarkable for its economy, and that steam winding was likely to be consigned to oblivion at no distant date. It is this remarkable diversity of opinion which stamps the controversy as somewhat unique, inasmuch as both the leaders are electrical engineers, who are unlikely to have any bias in favour of steam winding, while the fact that both start out with the same data, and arrive at exactly opposite results, suggests that subtle skill in handling figures hitherto supposed to be the exclusive property of those who take part in the fiscal controversy.

After a lengthy dissertation on the ease with which figures may be made to prove anything, Mr. Hooghwinkel takes as a basis 25 lbs. of steam for useful horse-power at the winding rope for electric winding, and 100 lbs. for a steam winder, and proceeds to draw general conclusions therefrom. There is really no fundamental difference between the case as presented by Mr. Mountain and Mr. Hooghwinkel, for both are practically in agreement as to the steam consumption for the electrical winder, and Mr. Mountain's figures for steam winding show that about the worst examples of this method use about 130 lbs. of steam per horse-power at the rope; and the best, viz., Messrs. Markham and Fraser & Chalmers' estimate, lead us to suppose that their steam winders deliver a useful horse-power at the rope for about 50 lbs. of steam. This is the first point where the leaders of the controversy diverge, for Mr. Hooghwinkel right through his paper assumes the steam winder to be incapable, under working conditions, of doing better than 1 h.-p. hour at the rope for 100 lbs. of dry steam at 100 lbs. pressure.

Fortunately it does not appear necessary to adopt this method of figuring the relative efficiency of the two systems, though it may be remarked in passing that with a modern condensing steam winder working at 150 lbs. per square inch, 50 lbs. of steam per useful horse power is by no means unusual, and even better results can be obtained.

The efficiency may be deduced by taking the available data in both papers, and by adoptinga slightly different method of analysis it is proved that while Mr. Mountain was somewhat unfortunate in choosing the Grand Hornu Mine as a typical example of electric winding, because this particular winder is of an uneconomical type, and operated by a system which is not conducive to economy, viz., a single direct connected motor without a balancer, he was nevertheless very much nearer an accurate conclusion than Mr. Hooghwinkel.

Table I. shows the salient features of three steam winders from Mr. Mountain's paper, viz., these at Bolsover Colliery Coy., Denaby and Cadeby, and the Richard Evans Collieries, indicated as 1, 3, and 2 respectively; these were chosen as typical low pressure (80 lbs.), single expansion winder, and therefore not remarkably economical. This table shows that 1·08 to 1·15 tons of coal are used per 100 tons of coal wound from the mine. The depth of shaft in each case has been chosen to give figures comparable with other examples of winding from similar depths.

TABLE I. — PERFORMANCE OF LOW PRESSURE STEAM WINDERS.

Ref No.	Depth of Shaft.	Total Coal wound per day.	Weight of Coal consumed per 100 tons wound.	Cost of Coal per 100 tons wound.	Value of Coal per ton
	yards.	tons.	tons.	*s. d.*	*s. d.*
1	372	2,000	1·08	2 8½	2 6
2	550	1,260	1·15	5 1½	4 6
3	763	3,360	1·11	1 8	1 6

Table II. shows the figures given by Messrs. Markham & Co. for compound high pressure (150 lbs.) winding engines, and may be considered as examples of the best which a steam winder can do.

TABLE II. — PERFORMANCE OF HIGH PRESSURE STEAM WINDERS.

Depth of Shaft.	Total Coal wound per day.	Weight of Coal consumed per 100 tons wound.	Cost of Coal per 100 tons wound.	Value of Coal per ton.
yards.	tons.	tons	*s. d.*	*s. d.*
500	1,500	·44	1 6½	3 6
700	2,000	·57	2 0	3 6

We need not at this stage take capital charges and operating expenses into account. The point to be settled is the relative economy of the two methods, for the question of capital is more easily settled than that of operating expenses, and the chief difference between the controversialists has been on the point of operating expenses, and this according to Mr. Hooghwinkel's paper turns on the difference of opinion on the fuel expense of winding.

Mr. Mountain made up three estimates of the cost of electric winding, two of which are reproduced in Table III., the only difference being that I have calculated the weight of coal per 100 tons wound from the cost of the coal. There are in addition, the figures for Zollern II. mine from Table I. of Mr. Hooghwinkel's paper, and a calculated figure for the coal used if the shaft were 500 yards deep; the coal consumed per 100 tons wound being taken in proportion to the depth of the shaft. This is theoretically correct, and practically it is correct within a few per cent. The reason why the figures given in Table I. do not vary in proportion to the depth of the shaft, is obviously due to the fact that the equipments themselves differ, but it will be seen from Table II. and the first

TABLE III.—PERFORMANCE OF ELECTRIC WINDERS.

Name of Mine or Authority.	Depth of Shaft.	Total Coal wound per day.	Weight of Coal consumed per 100 tons wound.	Cost of Coal per 100 tons wound.	Value of Coal burnt per ton.
	yards.	tons.	tons.	s. d.	s. d.
Mr. Mountain's calculations	500	1,500	0·38	1 4	3 6
Ditto...	700	2,000	0·51	1 9½	3 6
Zollern II. (Mr. Hooghwinkel) ...	330	2,500	0·2	0 6	2 6
Ditto, calculated for a 500 yard shaft...	500	2,500	0·305	0 9·1	2 6

two examples in Table III. that the assumption made in the last example in Table III. is quite justifiable. It will be apparent therefore, that on the coal consumption of the electrical winder, no difference exists between Mr. Hooghwinkel and Mr. Mountain, the figures for a 500-yard shaft being practically in agreement, and also that experience at the Zollern II. mine practically confirms the latter gentleman's figures.

It is now necessary to take into consideration wages and capital charges. With regard to the first of these it does not appear from either paper that there is any difference in the wages for steam or electrical winders. It is true that Mr. Hooghwinkel states that some saving may be effected with an electric winder as the attendant need not be such a highly trained mechanic, which is true; but the fact remains that the man in charge of a colliery winding plant is not often a highly skilled mechanic, and his wages are generally the irreducible minimum which that class of operator will accept, quite irrespective of whether the motive power is steam or electricity, so that no saving of any importance can be effected under this head, and we come at once to the question of capital charges.

Table IV. shows the capital cost, the cost per annum at 10 per cent. for interest and depreciation, and the capital cost per 100 tons wound:—

TABLE IV.—WINDING COSTS BY STEAM AND ELECTRICITY.

Nature of Drive.	Depth of Shaft.	Total Coal per day of 8 hours.	Days per Annum.	Capital Cost of Winding plant.	Interest and Depreciation charges per 100 tons wound.	Fuel per 100 tons wound.*	Interest and Fuel Costs per 100 tons wound.
	yards.	tons.		£	Shillings.	s. d.	s. d.
Steam	500	1,000	250	4,050	1·32	1 1½	2 5
Electricity	500	1,250	250	14,000	4·5	0 9¾	5 3¾

In order to make the basis of this table quite clear it should be explained that the figures for steam have been taken from Table III. of Mr. Mountain's paper, and are given in detail in Table II. of this article. As the discussion did not damage these figures they may be assumed to be correct, while the figures for electric winding have been taken from Table I. of Mr. Hooghwinkel's paper for the Zollern II. mine, the coal per 100 tons wound being increased in the ratio of 3·3 to 5 to get the amount for the 500-yard shaft. As the Zollern mine handles 2,500 tons of coal on a 16-hour shift, the output is halved in Table IV. to get an output comparable with the figure for steam.

It will be seen that the result shown in Table IV. is decidedly unfavourable to electricity, but as the electric figures are those of Mr. Hooghwinkel, and the steam figures those of Mr. Mountain and the firms already mentioned, they show the best that either side can do for their case, under the circumstances.

It should, however, be noticed that the more expensive coal becomes, the greater the advantage of electricity, until a point is reached—in this case at 10s. per ton, beyond which electric winding is cheaper than steam, for then fuel exerts nearly as much influence as capital charges.

Another point is that a mine working long hours is specially favourable to electricity, as by doubling the output, while it does not appreciably influence the fuel costs, per 100 tons wound, halves the capital charges. If the mine Table IV. worked sixteen hours the cost per 100 tons wound becomes 3s. for electricity, and 1s. 9¾d. for steam. Should it be worked twenty-four hours per day, with an output of 3,000 tons in the case of steam, and 3,750 in the case of electricity (Table IV.), then electric winding would become cheaper than steam winding, when fuel reached a price of about 3s. 6d. per ton; below this steam is most economical, above it electricity. Table V. shows this in detail.

It will be apparent, therefore, that the truth,

* Fuel figured at 2s. 6d. per ton.

TABLE V.—STEAM AND ELECTRIC WINDING ON 24-HOUR OUTPUT. COAL AT 3s. 6d PER TON.

Nature of Drive.	Depth of Shaft.	Coal raised per day.	Interest and Depreciation on Winding Plant per 100 tons wound.	Fuel cost per 100 tons wound.	Sum of Two Foregoing Items.
	yards.	tons.	s. d.	s. d.	s. d.
Steam	500	3,000	0 5½	2 2	2 7½
Electricity..	500	3,750	1 6	1 1	2 7

as is usual in such cases, lies between the two positions taken up by the controversialists.

Both gentlemen have performed a valuable service to the profession in themselves discussing, and inducing others to discuss, a subject on which opinion has been sharply divided for quite a long time. Its importance to the electrical engineer consists in the large capital value of even a single equipment, while to the mining engineer the gradual rise in the value of coal with the increasing depths at which it must be worked, will naturally compel the introduction of electric winding, even if for a few years yet, the economic advantages of electric winding are only recognised in the case of mines producing high-class steam or gas coal, where the value of fuel, even at the pit mouth, is considerable, and but a small percentage of fuel of low market value is produced.

Another paper read to the Institution of Electrical Engineers dealt with the electrical equipment of the Aberdare Collieries of the Powell Duffryn Company.

Nine pits are served from a three-phase generating station, having a capacity of 3,000 kilowatts. The total horse power in motors at the various pits amounts to 4,710, out of a total of over 12,000 horse power, the bulk of the power being for pumping, haulage, and pithead machinery, although two small electric winding engines are used, one being an underground winder in a staple pit, and another in a new pit being opened out.

The capital cost of the plant is as follows:—

TABLE VI.—CAPITAL COSTS OF GENERATING STATION, ABERDARE COLLIERIES.

Power station: Buildings, steam plant, generators, switchboard, etc., £11 10s. per k.w.
Transmission and sub-stations: Overhead line, switchboards, transformers, £2 12s. per B.H.P.
Motors, controllers, gearing: A sum varying from £3 18s. to £6 10s. per B.H.P.

The present output is at the rate of 4½ million units per annum, with a load factor of 37 per cent., and the costs are as follows:—

TABLE VII.

Works costs: Coal, oil, stores, and labour in generating station, ·18*d*. per unit.
Interest and depreciation on power station, ·185*d*. per unit.
Total cost per unit, * ·365*d*.

It is expected subsequent developments will reduce the costs to ·3*d*. per unit.

* 1⅓ horse-power hours.

The Electric Equipment of the new Cunarders.—The largest electrical installation ever fitted on any ship will be installed on board the new express steamers *Mauritania* and *Lusitania*. About 2,300 h.-p. of generating plant will be fitted on board each vessel, and practically all power will be distributed throughout the vessel by electricity. There are two electric passenger elevators to convey the passengers between the six decks, and there are smaller hoists for the conveyance of baggage and mails. Sixty electrically driven ventilating fans are fitted, the air being heated before being delivered into the passenger quarters in winter. In addition, there will be sixteen fans for forced draught, each driven by a 50 h.-p. motor. The lifeboats will be handled by electric motors, and the various capstans will also be electrically operated; even the sounding line will be heaved electrically.

On the bridge deck there will be four powerful searchlights and two masthead and sidelights, the latter being fitted with duplicate lamps, which are automatically switched into circuit when a filament breaks.

The lighting of the ship itself necessitates about 5,000 lamps, each of 16 c.-p., while the machines in the bakery, pantry and galley are driven by electric motors. The steam whistle is electrically controlled, and the watertight doors in the bulkheads are closed automatically by electric control from the bridge.

A complete telephone installation is to be provided, connecting not only the principal offices of the ship and the passengers' quarters, but telephonic communication will be established with the forecastle head, engine room, and the wheel house aft.

The generating plant will consist of four 375 k.w. Parsons direct current turbo generators, placed in two separate compartments aft the main engine room. The two compartments will be separated by a watertight bulkhead, so that they are quite independent.

Electric Power from Blast Furnaces.—In our March issue, we dealt with the possibilities of blast furnace gas for power production in connection with electro-metallurgical operations, and Mr. W. H. Booth, who, with Mr. Thwaite, has for many years advocated the more extended use of blast furnace gases for power production, recently pointed out in the columns of the *Electrical Review*, that, properly developed, such blast furnaces might

prove of great value for electro-chemical operations. That the value of these gas power plants is recognised on the Continent of Europe there seems no doubt, inasmuch as nearly a quarter of a million horse-power is now derived from gas engines operated by blast-furnace gases, while our American friends seem likely to give the question a good deal more attention than it has hitherto received, judging from the paper read some little time ago to the Western Society of Engineers, in which the subject is investigated at some length.

It is shown that about half the gas produced in the blast furnace must be employed for heating and compressing the blast and auxiliaries, leaving about 50 per cent., or in the case of the two furnaces having a capacity of 400 tons each per day, about 2,000,000 cubic feet per hour, which at 9,000 B.T.U per h.-p. hour, gives an available horse power of 20,000, after all the requirements of the furnaces are met.

TABLE VIII. — COST OF GAS DRIVEN ELECTRIC GENERATING PLANT.

Gas Engines...	£88,333
Electric generators and switchboard ...	£33,854
Buildings	£9,375
Gas scrubbing plant	£6,979
	£138,541

Total capacity of station = 6,400 k.w.
Capital cost per k.w. installed, £21 10s.

Taking a 10,000 h.-p. electric generating plant, made up of seven gas-engine units of 1,500 h.-p. each, with an eighth as standby, coupled to 25 cycle three-phase generators of 800 k.w. each. (The generators seem rather too small for the engines when judged by European experience, though, perhaps, they have been less fortunate with large gas engines in the United States.) The above figures show the estimated cost of such a plant.

If a gas holder is added in order to equalise the flow of the gas, and to supply the engines during a temporary cessation of the blast, the cost would be increased by another £7,000, raising the cost per k.w. installed £22 15s. 6d.

It is interesting to note that this is practically twice the capital cost per k.w. of a steam plant, such as that installed at the Aberdare Collieries (Table VI.). The estimated cost of operating such a plant at about three-quarter load is given as ·275d. per unit, the actual cost at Messrs. Cockerill's works, Seraing, being ·206d. per unit. It is interesting, in view of the comparison of the capital cost of the gas plant with the steam plant at Aberdare Collieries, to note that the costs of production at the latter is ·365d. per unit (Table VII.). In other words, the gas plant costs about 90 per cent.* more per unit installed, and effects a reduction of 43½ per cent. in the cost of production.

The plants are not strictly comparable on account of the difference in size, but the steam plant at Aberdare has reached such a size that even with much larger capacity the capital cost per k.w. could not be much lower than it now is.

* Were the generators more liberally proportioned in view of the large size of the engines, the capital cost would be about 80 per cent. instead of 90 per cent. extra.

Abstracts from the Continental Press.

Sinking the Syphons of the Hamburg Main Sewer.—The new Hamburg main sewer has to cross under three branches of the port, over distances ranging from 250 to 450 yards, in each case by means of a double syphon 80 in. in diameter. The pipes for this purpose were fitted up in several lengths (five in the case illustrated in Fig. 1), which were then towed into the river and hoisted so that their ends rested on derricks at a sufficient height above the water level to offer no obstruction to the traffic. Each section of pipe was converted into a caisson by means of partitions, and fitted with bolted flanges, then filled with water and lowered by steam winches, being moored as shown in Fig. 2. After the insertion of a leaden ring, the flanges were bolted together by divers, and the pipes emptied by an 18 h.-p. electric pump, the partitions being then removed.—*Zeitschrift des Vereins deutscher Ingenieure.*

Utilising Exhaust Steam in Low-Pressure Turbines at Collieries.—According to Hundt (*Glückauf*) the Rateau accumulator for utilising exhaust steam in low-pressure turbines has already been installed at twelve ironworks and collieries, including the Steel Co. of Scotland (Glasgow) and the Hucknall Torkard Co. (Nottingham), whilst seventeen other installations are in course of construction, including two sets at Messrs. Barber, Walker & Co.'s (Doncaster) and the Powell Duffryn Co.'s works. The accumulator is of different types; the vertical form, in use at the Poensgen ironworks, Düsseldorf, and shown in Fig. 1, consists of an old boiler, 13 ft. in diameter and 19 ft. high. It is filled with open water pans in two sets, forming an inner and outer ring of twenty-five and forty pans respectively, there being twenty layers or 1,300 pans in all. The exhaust steam is admitted from below and circulates between the pans, from the outside towards the centre in the lower half of the boiler, and from the centre outward in the upper half. The boiler weighs 15½ tons, the iron pans 115½ tons, and the water 34 tons.

A cheaper form, but suitable only for small turbines, consists of an old horizontal boiler packed with 85 tons of rails, laid crosswise, and supplied with exhaust steam from the winding and pumping engines.

The newest type of water accumulator is the form illustrated in Fig. 2. It is used in connection with a collector, which also serves as an oil separator, and is divided into two compartments so that some of the steam, when required, can be passed direct into the condenser. This form is specially designed for plant where the consumption of steam varies at different times in the day. The accumulator is a horizontal boiler, divided into two compartments by a horizontal partition. The steam pipes in both chambers are elliptical and perforated with a number of fine holes increasing in diameter downwards in order to ensure uniform distribution all round, the object being to keep the water constantly moving and diminish the resistance to below 0·15 atmosphere. A connection between the two chambers automatically equalises the pressure and water level, and the latter can also be read off in the gauge glasses outside The dimensions of the accumulator are generally so chosen

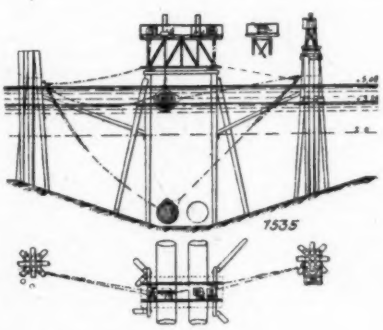


FIG. 1.

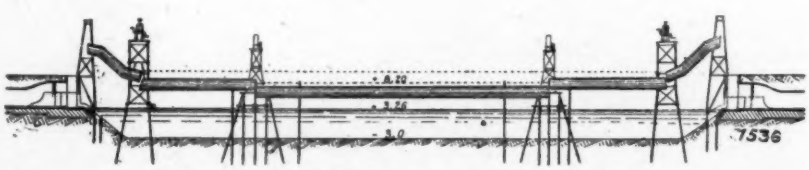


FIG. 2.—SINKING THE SYPHONS OF THE HAMBURG MAIN SEWER.

that with a maximum pressure of 1·125—1·3 atmospheres, the main engines may be stopped for a couple of minutes at a time without affecting the working of the turbines. To provide for the contingency of a shortage of steam, a second safety valve is provided, which admits live steam from the boiler into the accumulator when the pressure falls below a given level; but as the use of live steam is uneconomical it should only be employed in emergencies, and the accumulator should be large enough to work under half or three-quarters load and connected with another generator unless a reserve of steam is available from engines exhausting into a condenser. Both accumulator and pipes should be covered with insulating material, to save loss of heat by radiation.

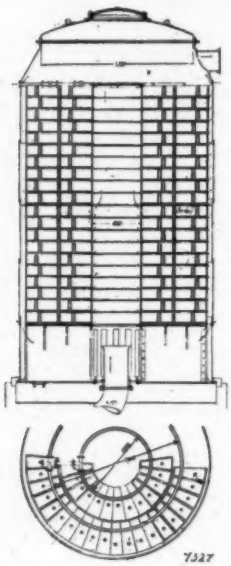
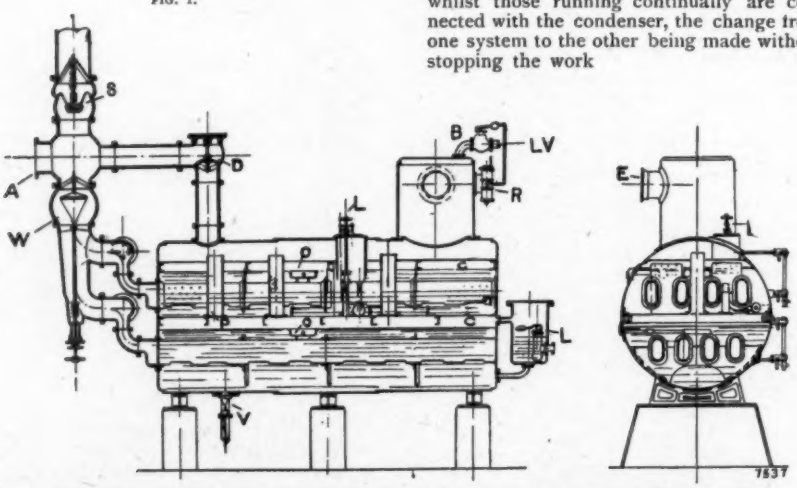


FIG. 1.

In the plant in use at the Klein-Rosseln colliery, a single accumulator is used for supplying two turbines (500 and 300 k.w.). A collector for the live steam and a vacuum exhaust cylinder common to the two turbines, are mounted in the engine house. Owing to the irregular steam consumption, especially by the winding engine, both turbines are run in the morning shift, but only the larger one in the afternoon and the small one at night. The disposition of the plant is such that all the engines at the colliery may either exhaust into the collector or the accumulator, or into the condenser, or again, the intermittent engines (winding, etc.), may exhaust into the accumulator whilst those running continually are connected with the condenser, the change from one system to the other being made without stopping the work



S = Safety valve.
A = Exhaust steam intake.
W = Return water valve.
D = Pressure equalising valve.
O = Oil skimmer.
P = Steam distributor pipes.
V = Draw-off valve for water.
L = Waterlevel float.
B = Pressure reducing valve.
LV = Live steam valve.
R = Pressure regulator.
C = Water level.
E = Exhaust.

FIG. 2.—UTILISING EXHAUST STEAM IN LOW-PRESSURE TURBINES.

Transporter Bridge at Marseilles.—The new transporter bridge at Marseilles crosses the mouth of the old port, to facilitate communication between the Catalans quarter and the Joliette docks. The distance between the centres of the two lattice towers is 542 ft., the towers themselves being 283 ft. above low water level and connected by the bridge platform at a height of 164 ft. The two end sections of the bridge, suspended on cables, are 214 ft. long between the towers, and the central section is 113 ft. in length. The rearward portion of the north end section is 134 ft. long, that of the south end section being 119 ft., and both are connected by cables to anchors embedded in ferro-concrete blocks and stone. The slung low-level ferry is 33 ft. long by 39 ft. wide, 26 ft. of this being roadway and the rest sidewalk.

The foundations for the towers consist of four stone pillars, 65½ ft. apart between centres in the transverse direction and half that distance longitudinally, embedded more than 10 ft. in the bed of the port. Access from the quay to the ferry is provided by ferro-concrete bridges, supported on the quay wall on cross beams between the pillars, and on ferro-concrete piles.

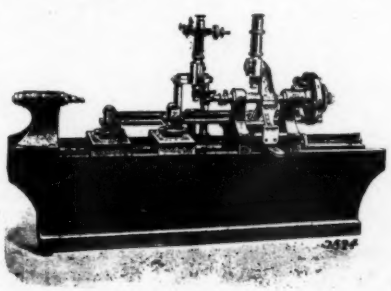
In hoisting the central section of the bridge into position—which was effected by means of four electric winches on the end of each fixed section—precautions were taken to prevent accident in case of the cable breaking. These consisted in passing a cable from each end section through cast steel blocks at the ends of the central section, the blocks being fitted with spring wedges arranged to operate and act as a brake in the event of the section falling.

Machine for Fine Measurements.—In a recent issue of *Der Mechaniker*, Dr. Gradenwitz describes a machine constructed by the Soc. Genevoise pour la Construction d'Instruments de Physique and capable of measuring down to 0·002 mm. The chief point of difference between this and other machines for the same purpose is the immobility of the microscopes, the standard measuring scale being the movable part, since this is considered to reduce the sources of error to a minimum. The micrometer screw is carefully cut, and has a pitch of 0·5 mm., wear being compensated by a second nut screwed on to the first and adjustable at will. One of the fixed microscopes is used for reading off the standard scale of Invar metal (nickel steel), the other for reading the contact marks or zero point. Constant pressure at the contacts is secured by making one movable and acted on by a spring at a marked place so chosen that, when the contacts come into action, the mark is exactly under the adjusting microscope, whilst the zero point of the standard scale comes into position under the other microscope. To take a reading, the mandrel is advanced until it touches the object, and then fixed, the adjusting screw being next turned until a mark on the spring counter poppet is opposite the cross threads of the microscope. The machine will measure to $\frac{1}{1000}$th mm. Two sliding supports are provided for the object and can be adjusted to different heights.

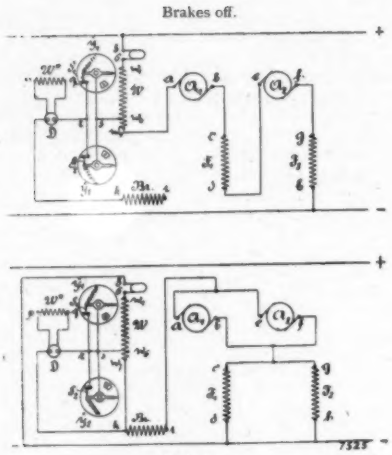
Failures of Tramway Brakes.—In dealing with the failure of brakes on electric tramcars, Kramer (*Elektrische Bahnen und Betriebe*) recommends the following device for indicating to the driver whether the brake mechanism is in order or not. Instead of connecting the brake conductors with the line wire, they are connected with two indicators, y^1 and y^2, arranged on the front and rear platforms and short-circuited by the switch when the brakes are put on. The indicator consists of a pointer, which a spring tends to force into the position of "danger," but which is restrained by a fusible plug S, until the latter is fused by the resistance set up as soon as any disturbance occurs in the brake circuit. As the pointer flies round to the "danger" mark on the dial, the injured part is disconnected from the line circuit, so as to prevent burning out and the resulting expensive repairs.

It is also pointed out that the brake mechanism may fail to act if the commutators are not clean, some kinds of greasy carbon forming a thin film on the commutator, insufficient to affect the running of the car, but hindering the passage of current when the brakes are put on.

"Pluto" Water-Tube Boiler.—The chief features in this boiler, says *Genie Civil*, are the arrangement of the water tubes with

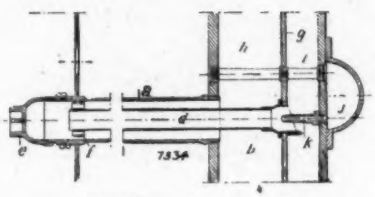


MACHINE FOR FINE MEASUREMENTS.



FAILURES OF TRAMWAY BRAKES.

their free ends toward the front of the boiler, the special form of tube joint, and the provision of a larger supply of feed water to the lower rows of tubes. The Field vaporising tubes, *a*, are 3¼ in. in diameter and fitted with internal circulation tubes, *d*. The front end of each tube is closed by a screw cap, *e*, whilst the rear end screws into the wall of the water chamber, *b*, the joints being made perfectly tight by means of conical shoulders, and circular grooves filled with a grease containing a large proportion of graphite which prevents rusting in the joints. To replace any of the tubes, all that is necessary is to unscrew the cap, *e*, draw out the inner tube, *d* (the rear end of which is supported by the partition wall, *g*, dividing the water chamber into two parts, *h* and *i*), and unscrew the tube with a key. The ease with which this can be done, greatly facilitates cleaning out the tubes and maintaining a clean evaporating surface, thus increasing the efficiency of the boiler. To secure a sufficient supply to the lower ranges of tubes, nearest the fire-box, feed water is admitted direct through a distributing pipe, *j*, on the back wall of the water chamber, jets, *k*, from this distributor delivering the water direct into the inner tubes, *d*. Owing to this arrangement each of the lower rows of tubes receives one-third to one-half the total quantity of water evaporated by the boiler, or more than it can vaporise, and there is therefore no danger of these rows getting short of water.



"PLUTO" WATER-TUBE BOILER.

Benzine-Electric Train.—A narrow gauge train hauled by electricity generated by a benzine motor has been tried in Russia, for military purposes, says the *Elektrische Bahnen und Betriebe*. The train consists of six bogie trucks, each weighing about 14 cwt. and carrying a load of 34 cwt., mounted on 12-in. wheels running on a 28-in. track of 10-lb. Vignole rails. The generator consists of a four cylinder 4-cycle Germain benzine motor mounted on the leading truck of the train and developing 35 h.-p. at 800 revolutions per minute. The Bergmann dynamo driven by this motor furnishes a current of 142 ampères and 120 volts at 780 revolutions per minute, and can deal with an overload of 20 per cent. prolonged for some considerable time. In working order the weight of the motor, dynamo, and accessories is nearly three tons, or 3 cwt. per kilowatt. Each of the truck bogies (twelve in all) is fitted with slung motors, engaging with the axles by pinion gearing reducing the speed to one-fifth ; and each motor weighs about 1 cwt., and runs at 1,000 revolutions per minute, with a tension of 60 volts at the terminals. Each pair of motors is coupled in series. The train is divided into two groups (of six motors) coupled in parallel, so that the whole behave like two motors. A speed of 7-10 miles an hour is attained, and the train will negotiate curves of 33 ft. radius without difficulty. The chief advantages claimed for this system are that, as 50 per cent. of the axles are driving axles, half the weight of the train is utilised in getting a grip on the rails, so that gradients can be ascended that would be impossible for steam locomotive haulage. The uniform distribution of the whole train, motor truck included, enables a lighter track to be used than with steam haulage. The system is suitable for dry regions, no water being required. The train is always ready, and can, if necessary, be worked by one man. When the train is standing, the motor truck can be used to generate current for lighting, power, or other purposes.

METALLURGICAL PROGRESS

By PERCY LONGMUIR.

STEEL, ITS PROPERTIES AND TREATMENT.

Reactions of the Open Hearth Process.—In a paper read before the "Sheffield University Chemical Society," Mr. R. Mather succinctly describes the reactions of the Open Hearth Process. At the outset the acid and basic processes are briefly indicated, and emphasis laid on the essential part played by the refractory linings. Thus, whilst the highest function of the material forming the hearth is to remain neutral, this end can only be attained by accommodating the lining material to the method followed. As Campbell has shown the lining has very little influence on the metal, but the nature of the bottom determines the character of the slag that can be carried, which in turn determines the character of the process. The difference then between acid and basic processes is reflected in the difference between the linings used. Taking the acid process first, which, as indicated by name, is conducted on an acid-lined hearth, it is shown that the amount of oxidation previous to melting varies with the nature of the flame, the arrangement of the charge, and the amount of scrap it carries. An effort is therefore made to oxidise as much as possible of the carbon silicon and manganese without oxidising iron which would lead to unnecessary waste and possibly to the formation of silicate of iron, due to combination of the oxide with the silica of the hearth. After melting, the bath of metal is protected by a layer of slag, and oxidation due to contact with air then ceases. Further, oxygen is added in the form of a rich hematite ore, the extent and rapidity of these additions being determined by the character of the steel required. Thus, in the case of a 50-ton charge running for a mild heat, 20 cwts. of ore were added as soon as the metal was melted, 15 cwts. were added after a lapse of twenty minutes, and 10 cwts. after a further interval of ten minutes, giving a total addition of 2½ tons of ore in the first half-hour after melting. The addition of ore giving rise to vigorous chemical action causes violent frothing, which keeps the metal in circulation, ensuring contact between metal and ore in all parts of the bath. The subsidence of this frothing is an indication that the ore is becoming worked out and further additions are required. The ore is reduced by the impurities of the bath, owing to their greater affinity for oxygen. Of the three impurities to be removed, carbon, silicon and manganese are not all oxidised at the same rate; usually silicon and manganese are removed at a fairly similar rate, but during this period carbon is only oxidised to a slight extent. On the removal of silicon and manganese the rate of oxidation of carbon quickens, and the result is the formation of CO which escapes as a gas. The appearance of these bubbles of gas indicate the "boil," and from this point further additions of ore should be cautiously added. The additions should be so regulated that the boil is not too vigorous, which would result in over-oxidation; nor yet too slow, which would unduly prolong the time of working. On reaching the desired content of carbon as indicated by spoon samples from the bath, ferro manganese is added in order to eliminate suspended ferrous oxide.

Turning to a consideration of the slags of the acid process, these are formed of acid and basic oxides, the available ones being silica, oxide of manganese, and the two oxides of iron. Other materials present in the furnace carbon, sulphur and phosphorus, do not enter the slag, whilst the impurities of the ore, such as lime, magnesia, alumina, etc., are usually present in small and insignificant quantities. The formation of slag commences with the melting and the amounts of iron, silicon and manganese oxidised during the melting period, together with the sand adhering to the pig iron, all contribute to the formation of slag. After melting, when the slag forms a continuous layer and the ore additions commence, the slag tends to approach a constant composition as far as silica is concerned. The amount is about 53 per cent., but as in normal working the slag contains a slight excess of ferrous oxide, the actual content of silica is fairly constant at from 51 to 52 per cent. Once the whole of the manganese has been removed from the charge, the content of

MnO in the slag cannot increase, and any further base required by the silica has to be supplied by the iron ore. FeO and MnO appear to have an equal action in preserving the basicity of the slag, and, however much one of them may vary during the working of a charge, the other will vary in such a manner as to keep the combined content of FeO and MnO constant at about 45 per cent. In other words, the slag will almost always be of the same degree of basicity. If from any cause the silica of the slag rises then on further additions of ore FeO will be retained by the slag, and so counteract the excess of silica. On the other hand, if the total bases rise, the slag will act on the silica of the lining until equilibrium has been restored.

After detailing the operations followed in the basic process, the author passes on to a consideration of the slags, noting in the first place their complex character in comparison with those of the acid process. The main constituents are lime, ferrous oxide, and manganous oxide, which are basic with the acid constituents of silica and phosphoric acid. The amount of silica is practically fixed by the silicon of the charge, and the constituents requiring chief control are lime, ferrous oxide, and phosphoric acid. Lime is found to vary with the conditions from 45 to 55 per cent., but in any one heat it will remain fairly constant. With too much lime present the slag is thick and viscous, and in such a condition is not favourable to free working. Until a suitable fluidity is obtained any ferric oxide added to the bath will give up one atom of oxygen to the impurities, and the resulting ferrous oxide will be retained by the slag. Failing this a viscous slag will result in an oxidation of the metal, and the ferrous oxide formed will enter the slag until the requisite fluidity is obtained. In a certain sense this regulation of fluidity is automatic, and as such contributes largely to the success of the process.

Open Hearth Steel Castings.—In continuing his series under this heading, Mr. W. M. Carr, in the current issue of *The Foundry*, gives chief place to the brick work and linings of acid and basic furnaces. Producer gas and its generation is fully indicated, and some very pertinent remarks offered on the uses of liquid fuels in the open hearth furnace. In the author's opinion these fuels, such as crude petroleum, are more advantageous than gas, due chiefly to the greater thermal efficiency and the elimination of intermediate losses. It is, however, difficult to make an actual comparison between oil and producer gas on the basis of metal produced. The figures may be in favour of coal in certain localities, and in favour of oil in others. Yet the advantage of oil as against coal in working results are so pronounced that discrepancies in cost against oil are offset by its usefulness. Ignoring relative costs, the chief points in favour of oil against gas are as follows:—(1.) The higher thermal value. (2.) Simplicity of installation. (3.) Decrease in repair costs and increased working life of furnace. (4.) Oil not being subject to the same irregularity as producer gas, a decided gain in the regularity and certainty of the work of the furnace follows. (5.) Labour costs are lowered; thus one man per working day attends to the pumps pumping oil from the tank, as against several men attending a producer. Oil fuel will also be found useful for drying ladles, firing annealing ovens, core stoves, &c.

Piping in Steel Ingots.*—Mr. N. Lilienberg, in a paper before the American Institute of Mining Engineers, discusses piping and its remedies, arranging the latter into two classes: (1.) in which the steel is kept liquid, and (2.) compression of the ingot. The first class comprising methods which tend to prolong solidification is naturally accompanied by more pronounced segregation. Of these methods we note the following:—The addition of aluminium, either to ladles or moulds, is said to increase the heat by combining with the dissolved oxygen, and, at the same time, lowers the melting point of the steel. However, it is well known that aluminium does not realise the expectations formerly entertained, and whilst it tends to the production of a sound steel, it does not prevent piping. The addition of thermite gives a greater heat than aluminium alone, and its use makes the steel in the mould fairly sound. But inasmuch as the higher temperature cannot prevent the steel from solidifying first in the outer layers, a pipe will inevitably form, although it will be smaller in volume. Clay-lined funnels, placed on the top of the ingot moulds, shorten the pipe, because the steel does not chill so rapidly against the less conductive clay as against the bare mould. The piped portion of the ingot is afterwards removed, and represents scrap. The method of casting by overflow, that is from one mould to another, produces tolerably sound ingots, but has the disadvantage of making much scrap. It is also evident that the steel coming to the last mould is much cooler than in the first. The use of electricity in order to keep the upper part of the ingot hot is, apart from disadvantages to the life of the mould, more costly than cutting off the piped part.

Turning to the second class, methods of compression in the mould, the author states first that little or nothing can be gained by compressing liquid steel, which is absolutely sound and dead melted. Amongst the various compression devices the following are noted. Pressing from the top offers no difficulty if the whole charge enters one mould. Where several moulds are used, then the machinery becomes complicated, the moulds have to move in procession under the press, or several presses have to be employed. If the compression comes too late, the pipe is already formed and oxidised. and pressure will then only squeeze it together without eliminating it. Compression from the

* *The Iron and Coal Trade Review.*

bottom originated at St. Etienne, and is in use in several works. In the author's opinion this method suffers from the disadvantage of the top compression. In compressing from the sides the top may be left open, thus permitting the gases to escape, and the pressure may be applied directly in proportion to the formation of pipe, so as to keep the ingot always full to the top. Various difficulties in this direction will occur, but the problem of side compression in a stationary mould, has been successfully solved by Mr. J. Illingworth. The process consists in squeezing the two halves of a mould together, after they have been sufficiently opened to insert a plate between the ingot and the mould. This plate having a section of a segment of a circle displaces a corresponding volume of the semi-liquid interior. This apparatus has given good results for crucible steel, but is not so well adapted for large moulds poured from a bottom casting ladle. The problem of compressing large ingots cast from a ladle has been successfully solved by Messrs. Illingworth and Robinson, and ingots of the largest size, solid from top to bottom, are obtained. The principle is to cast the steel in divided moulds, held together during casting by hydraulic pressure. The joint edges of the half moulds are planed, and bars placed between them. After casting a crust is allowed to form, and whilst the interior is still liquid the bars are drawn from between the mould joints and pressure applied from a hydraulic ram, thus forcing the half moulds together. The volume of the bars corresponds as near as possible to the volume of the pipe which would otherwise be formed. Careful investigation has shown that during this side compression the surface of the ingot is neither crushed nor folded, but is merged in the mass. This action is akin to that of the roughing mill, although the circumstances attending compression are not so favourable as those of rolling. No groove is formed between the joints of the mould. If, in the case of special steels, there should be a tendency to this, the edges of the dividing bars may be made slightly convex, thus leaving concave grooves in the ingots which, by compression, straighten out to a plane.

Pipes and Blowholes.—This paper, read before the Sheffield University Students' Engineering and Metallurgical Society, covers very similar ground to the foregoing, and the author, Mr. E. L. Dickenson, is to be congratulated on his clear exposition of a notoriously difficult subject. At the outset, a sharp distinction is drawn between the defects of piping and blowholes, the former being the inevitable result of shrinkage, the latter representing the liberation of gas occluded during the steel-making process. The position of the pipe is determined by the conditions of cooling, and in order that the waste may be reduced to a minimum, the pipe should lie as high as possible; in other words, solidification should be more rapid in the lower than in the upper part of the ingot. The pipe is liable to be lowered by strongly tapering moulds and bottom casting. The volume of the pipe, assuming for the moment that it is not diminished by the formation of blowholes, is roughly proportionate to the difference of temperature at the outside and the average inside temperature at the time when the last freezing portion of the interior becomes plastic. This difference is greater when the heat is rapidly conducted away from the outside, hence the pipe should be greater in ingots cast in iron moulds than in those cast in sand moulds. Satisfactory data as to the total contraction of volume is not available, but the shortening effected by Whitworth's fluid compression suggests that the total contraction by volume is in the neighbourhood of from 13 to 14 per cent. Obviously, the formation of pipe should be prevented as far as is possible, and that piping which cannot be prevented should be arranged to take place in that part of the ingot where it will have the least harmful effect. Turning to blowholes, it is shown that these are due to the fact that fluid steel possesses the property of absorbing gases, which, under certain conditions, are wholly or partially rejected at the moment of solidification. The progress of solidification retards the escape of all the gases, bubbles of which are retained forming blowholes. When well in the centre of the ingot, these blowholes are less harmful than when nearer to the edge. For example, blowholes just under the skin of the ingot become connected with the atmosphere and their surfaces become oxidised, and consequently will not weld up on forging or rolling, but are drawn out into long thin rokes. Internal blowholes with unoxidised surfaces are welded together. Concerning the nature and prevention of blowholes, the author gives an admirable summary of Brinell's work in this direction.

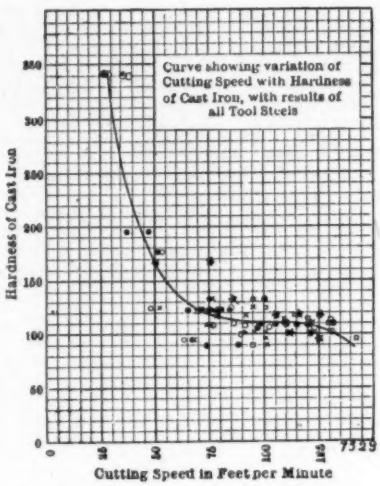
Turning to mechanical methods for minimising the formation of pipe, the author indicates in the first place fluid compression of the ingot as in the well-known "Whitworth" system. Daelen employed a strengthened ingot mould, which, after filling to the top, was compressed by means of a vertical plunger. Williams employs a mould, one of whose inner faces is concave. On solidification of the shell the mould is opened, and a plane convex plate placed between mould and ingot; and on compression of the sides the convex side of the ingot is driven in, thereby forcing the liquid steel from the interior into the already partially formed pipe. Harmet's method, the use of feeding heads, and Reimer's method of external heating are also indicated.

On the Manufacture of High-class Steel from Phosphoric Irons.—In a recent issue of the *Iron and Coal Trade Review*, Mr. W. Galbraith advocates a combination of acid and basic lined convertors working in conjunction with an acid Siemens furnace. The

proposed plant would consist of two small acid convertors, two small basic convertors, and a 12-ton Siemens furnace. It is suggested that molten metal be blown for a short time in an acid convertor, reducing the silicon from 2 to 0·3 or 0·2 per cent., and the carbon down to 2 or 2½ per cent. This metal is then blown in the basic convertor for dephosphorisation, separated from its basic slag, and transferred to the Siemens furnace in the presence of an acid slag. These operations may be repeated until the Siemens furnace is full, the requisite additions made, and the furnace tapped as usual.

Tests of High-speed Tool Steels on Cast Irons.*—Professor Breckenridge and Mr. H. B. Dirks place on record a series of experiments conducted with various high-speed tool steels on a series of cast irons of varying hardness. Practically the whole of the tool steels used proved equally effective. However, a point of great value in the paper lies in the compilation of a table showing the variation of cutting speed with the hardness of cast iron. The appended figure shows advisable cutting speeds on grey iron of varying hardness, and is deduced from the results of all the tests of the different steels used.

The hardness figures of the grey iron castings were obtained by means of a drill test, in which 100 is assumed as the standard hardness of grey iron. The curve shows that (*a*) any of the steels tested can remove very hard grey iron at a rate of 125 feet per minute; (*b*) that all the steels tested begin to wear rapidly at speeds a little above 125 feet per minute. Between these two points the relation between a safe cutting speed and the hardness of the iron seems to be definitely expressed by the curve. It would seem that grey iron of medium hardness. 100 to 120, could be cut at 125 feet per minute just as readily as at 70 feet per minute, as far as any injury to the tool is concerned.


Curve showing variation of Cutting Speed with Hardness of Cast Iron, with results of all Tool Steels
Hardness of Cast Iron
Cutting Speed in Feet per Minute
7329

TESTS OF HIGH-SPEED TOOL STEELS ON CAST IRONS.

Electric Smelting.†—Dr. Haanel, speaking in Toronto on the recent experiments in electric smelting at Sault Ste Marie, said that the questions to be settled were:—(1) Can magnetite be successfully smelted? (2) Can iron ore of high sulphur content be made into pig iron of marketable value? (3) Can charcoal be substituted for coke? and (4) The amount of electric energy required per ton of pig iron produced. In all, some 150 casts have been made, yielding 55 tons of pig iron. Canadian magnetite ore high in sulphur has been found to yield a product containing only a few thousandths of 1 per cent. sulphur. The experiments had reduced the cost of electrodes to 30 cents per ton of pig iron produced as against 77 cents, which was the cost in the French experiments. The cost of developing electric energy from water power near ore deposits is estimated at from 4·50 to 6 dollars per horse power annually. The foregoing is extracted from a preliminary statement, as the experiments have been conducted under the supervision of Héroult, the publication of an official report should give much of very direct value on the question of electric smelting.

* University of Illinois Engineering Experiment Station and *American Machinist*.
† *The Iron Trade Review*.

FOUNDRY PRACTICE.

Semi-Steel Castings.—Mr. A. Maloné, in *The Iron Trade Review*, pointedly remarks that there is no profound secret connected with these castings. In a word, they are simply cast iron in which the carbon and silicon have been lowered by the introduction of low carbon material. In practice the writer finds that the best method of introducing steel scrap is found in plate shearings or punchings, or in the ends cut from shafting. Thin sheet scrap, fine punchings, and borings should be avoided, as this class of material will work to the lower edge of the melting zone, and be almost wholly burnt or oxidised.

Distribution of Blast in Modern Cupola Practice.*—Mr. W. H. Coleman shows at the outset that the excessive pressures advocated in some quarters are not practised by intelligent foundrymen. The bad effect on cupola lining and quality, of metal, of high

* Chicago Foundry Foremen's Club and *The Iron Trade Review*.

pressures are indicated, and whilst it is true that high pressures give a greater melting capacity for a given size cupola, it is also equally true that better results can be obtained by using a larger cupola with lower pressure and larger volume of air supplied through enlarged tuyere area. Investigation has shown that the volume of air required to melt a ton of metal per hour depends upon the size of the cupola and the ratio of coke to metal used in melting. The following table illustrates this:—

Melting Ratio.	Volume of Air.
10 : 1 ...	25,000 cub. ft. per hour per ton of iron per hour.
9 : 1 ...	27,000 " " " " "
8 : 1 ...	29,000 " " " " "
7 : 1 ...	31,000 " " " " "
6 : 1 ...	33,000 " " " " "

Having a cupola of sufficient capacity, with a total tuyere area equal to 20 per cent. of the area of its inside diameter, and with a fan blower fitted with a blast gate and delivering the required volume through a pipe whose area is not less than one-third of the combined tuyere area, then ideal conditions are presented for using low pressures. Under such conditions the following melting capacities would be obtained:—

Internal diameter of cupola.	Capacity per hour.	Pressure.
Inches.	Tons.	Ounces.
18	½ to ¾	5 to 7
23	¾ " 1½	5 " 7
30	2 " 3½	6 " 8
35	3 " 4	7 " 8
37	4 " 5	7 " 10
42	5 " 6	7 " 10
45	6 " 7	8 " 10
48	7 " 8	8 " 10
54	8 " 9½	9 " 10
60	10 " 12	10 " 12
66	12 " 15	10 " 12
72	16 " 18	10 " 12
78	19 " 22	12 " 14
84	22 " 24	12 " 14

Moulding Sand.—Mr. E. H. Field, in a paper before the Pittsburg Foundrymen's Association, deals at full length with these sands. The various constituents of typical moulding sands are described in detail, and good sands on ultimate analysis are shown to vary within the following limits:—

Total silica	75 to 85 per cent.
Alumina	7 " 10 "
Lime	Below 2 "
Alkalies	Below 0·5 "
Oxide of iron	Below 6·0 "

The combined total of iron oxide, lime and alkalies, or the total fluxing agencies should not ordinarily exceed 7 per cent. in any one sample. In a high grade moulding sand, used for heavy work, they should not exceed 5 to 6 per cent. Throughout the paper the author draws a sharp distinction between free or quartz silica and combined silica present as a silicate. Thus a sharp sand on ultimate analysis yields:—

Silica	80·67 per cent.
Alumina	9·30 "
Iron oxide ...	4·53 "

Expressing the same results by more rational terms, the following is obtained:—

Quartz silica	67·85 per cent.
Clay content, including iron oxide ...	22·03 "
Clay content, excluding iron oxide...	17·50 "
Felspar	10·12 "

The refractory properties of moulding sands are largely determined by the contents of quartz silica and clay. Porosity is determined by (1) the proportion of quartz silica to the bond or clay, (2) the size of the quartz silica particles, (3) the shape of the quartz silica particles, and (4) the condition of the bond. Generally speaking, the higher the amount of quartz silica the greater the porosity, and also the larger the size of these particles the more open the sand. A limit to size is, however, found in the fact that coarse sand will not give the requisite finish and skin to the castings. As far as shape is concerned, irregular crystalline particles with sharp edges and corners will leave greater spaces between the particles than will regular particles with smooth surfaces, which are apt to fit closely together and thus prevent a free passage of gas or air. As regards the condition of the bond, it is shown that the tendency of the clay is to bake together, and so destroy the porosity. The best results are therefore obtained with a sand containing a low percentage of strong bond rather than with a sand containing a high percentage of weak bond.

Research Work at the National Physical Laboratory. — *The Effect of Wind Pressure on Structures.* (*Dr. Stanton and Mr. Bairstow*).—The work during the year has been mainly confined to making observations on the resultant wind pressure on two rectangular plates, one 10 ft. by 10 ft. and the other 10 ft. by 5 ft. The method adopted has been that alluded to in the previous year's Report,* *i.e.*, of taking simultaneous observations of the velocity head of the wind and the resultant pressure on the plate. Owing to the very considerable differences in wind pressure which are known to exist even in a steady breeze at points distant 10ft. or more apart, it has been found necessary to take a very large number of observations in order to obtain a reliable mean result. The number of observations made on the large board has been, approximately, 150, and for the smaller board, 100, and it is considered that within the limits of wind velocity available during the year, these are sufficient to justify a mean being taken for speeeds up to 25 miles per hour, but for speeds greater than this, a sufficient number of observations are still lacking. The experimental data already obtained appear to indicate that for the same wind velocity the mean intensity of pressure is the same for a board of 100 sq. ft., as for a board of 50 sq. ft., and, further, that the value of the constant does not differ greatly from that obtained from experiments on small models in a uniform current of air.

The Resistance of Materials under Alternating Stresses. (*Dr. Stanton and Mr. Bairstow*).—This work has continued throughout the year, and a research on the resistance of certain qualities of iron and steel in common use by engineers has been completed. The results obtained were given in a paper before the Institution of Civil Engineers, an abstract of which is given on p. 386 of this issue.

Tests on Pressure Gauges. (*Dr. Stanton and Mr. Bairstow.*)—The proposed tests on pressure gauges, suggested in the Report for 1904, have been carried out. Ten gauges were subjected to tests to determine the effect of friction, backlash, temperature and vibration, together with endurance tests. The vibration tests were made at three different periods and amplitudes of vibration, and showed that considerable disturbance of the gauge pointer was produced in the case of all the unbalanced gauges, and that the balanced gauge was practically unaffected in all cases.

The Specific Heat of Superheated Steam. (*Mr. Jakeman*).—The experimental determination of the specific heat of superheated steam has been continued during the past year, and the apparatus* has been improved in several details. The steam is now thoroughly dried by passing through a gas-heated superheater before being used for the experiment. The initial superheat in this superheater can be varied from a few degrees only, up to 150° C or more. The steam is then heated a further 20 deg. in the electrically heated superheater, and the specific heat calculated is the mean for these 20 deg. The specific heat so obtained is taken as the specific heat at the mean temperature. The radiation loss has been rendered much more constant by enclosing the apparatus in an air-tight screen. Notwithstanding these improvements it was not found possible to obtain consistent results with experiments lasting from 15 to 20 minutes, even after allowing several hours for the apparatus to settle into a steady condition. It has, however, been found that if observations be taken very frequently for periods of 100 minutes after three to four hours' preliminary heating, the results obtained agree very fairly well; the maximum variation between similar determinations not exceeding 2 per cent. Five points have been determined with a pressure of steam of 4·3 atmospheres, one point at 7 atmospheres and one point at 9 atmospheres. The results obtained are fairly consistent, and it is hoped to publish them in detail very shortly.

The experiments are still proceeding, and the shape of the curve at 4 atmospheres will be first settled more closely by several more determinations, and the observations made at higher pressures to find the variations from the curve produced by increasing the pressure. The reliability of the method appears to be settled now beyond doubt; but, probably, it will be necessary to reconstruct the apparatus to obtain an accuracy closer than 2 per cent., and to provide a means of completing the determinations more quickly.

Metrology. (*Mr. Jeffcott and Mr. Attwell*).—An investigation has been carried out for the

* Cf. ENGINEERING REVIEW, vol. xii. p. 784.

* *American Machinist.*

Engineering Standards Committee with a view to the standardization of the different classes of fits of shafts and bearings, and the tolerances on interchangeable cylindrical parts of machines.

From measurements made on about 800 specimens of various diameters up to 12 inches, the average error was found to vary considerably with different classes of work, whilst in the same class of work it was found as a rule to increase with increase of diameter.

The specimens measured were taken from various kinds of engineering work, as under;—

Class of Work.	Error in Workmanship.	
	Shafts.	Holes.
	inches.	inches.
Large machine tools	0·0025	0·0033
Small tools	·0005	·0010
Locomotives	·0031	·0025
Gun mountings	·0012	·0014
Marine engines	·0018	·0028
Gas engines	·0020	·0028
High speed engines and dynamos	·0011	·0010
All specimens—average	0·0016	0·0018

Ground shafts were found to be on the whole more accurate than others which had been turned in the ordinary way. Thus: The average error in ground shafts, 0·0011 inches. The average error in shafts not ground, 0·0019 inches.

To determine the errors in workmanship in bolt heads, nuts and spanners, a number of each were measured up. The average measured errors in size across the flats are as follows:—

—	Error in Workmanship.	
	Diameter 1 in. and over.	Under 1 in. Diameter.
	inch.	inch.
Bright nuts	0·006	0·0025
Bright bolt heads ...	·006	·0045
Black nuts	·020	·0055
Black bolt heads	·027	·0080

A New Electric Incandescent Lamp.*—A new electric incandescent lamp, of a highly interesting character has been invented by Dr. Kuzel, of Baden, near Vienna, who has handed over the commercial arrangements for its application to Messrs. Fahn and McJunkin.

Dr. Kuzel's method is to reduce a number of colloidal metals of high fusing point—chromium, manganese, tantalum, molybdenum, thorium, and others — to a state of extremely fine division. The method is not stated, nor are the particular metals he employs in his experiment, but one way of doing it is to form an arc from the metals under water. This metallic froth mixed with water only forms a plastic mass which can be manipulated as though it were an extremely fine clay, and it is squirted or pressed through a die to form the filaments. These being formed are at first non-conductors (or second-class conductors) and they have to be raised to a temperature of 60°C. before they can conduct. On cooling they again become non-conductors, but if heated to incandescence, either by a current or in a furnace—in vacuo or an inert gas—they crystallise, and retain their metallic properties when cold. Since no binding material is used the filament is homogeneous; or if any binding at all be present it is a eutectic alloy of two or more of the metals employed. Dr. Kuzel claims that he is the first to produce such crystalline filaments from the colloids, any previous attempt in this direction having failed, since the dried metal fell to powder. He attributes his success to the presence of what he calls myelin forms, a sort of microstructural felting of the material employed. Experiments have been carried out at the lamp laboratory of Mr. Joh. Kremenezky, of Vienna, certified by the Elektrotechnische Gewerbemuseum, according to which a batch of lamps at 1 watt per c.p. had been burning for 3,100 to 3,500 hours, with an average drop in candle power of about 3 per cent. and a maximum of 11 per cent. Another batch at 0·75 watt per c.p. burnt over 1,000 hours with a drop under 5 per cent., and 1,600 before the decrease reached 20 per cent. The filaments are said to be cheap in raw material and in manufacture, the bulbs are the same size as used in ordinary carbon lamps, and the process of fixing the same. The voltages in the early experiments were low, from 20 to 60, but already 110-volt. lamps have been made, with double filaments, and 220-volt. lamps are contemplated.

Completion of the New Croton Dam.—The completion of the new Croton Dam, which was commenced more than thirteen years ago, and has cost over £1,600,000, exclusive of the land and inclusive of some fifteen miles of highways, is announced in the *Times Engineering Supplement*. This undertaking for the supply of water to New York is one of the largest constructions of the kind in existence, and in engineering importance ranks with the most famous waterworks in the world. The *Engineering Record* of New York*, contains a a very interesting description of the dam, from which the following important facts are taken. The dam is exactly 300 ft. high from the lowest point in the foundations to the crest, and is thus the tallest dam in the world. It forms a reservoir 18 miles long, and impounds

* *The Electrical Times*, No. 752.

* January 6th, 1906.

about 32,000,000,000 gallons of water. It is built of solid granite ashlar and rubble, except that the south extension is backed with cyclopean concrete, and it has a spillway 1,000 ft. long at right angles to the axis of the dam and 16 ft. below its crest, and contains altogether about 855,000 yards of masonry. The spillway is crossed by a steel arch bridge of 200 ft. span. A large power plant was permanently installed a short distance below the dam site. The river, which had a flood flow of 15,000 cubic feet per second, which was diverted by means of a canal 200 ft. wide and 1,000 ft. long cut in rock with a crescent-shaped wing dam at each end built of earth, stones, piles, and crib-work. The upper dam was 30 ft. high and joined a masonry wall 23 ft. high and 630 ft. long. These barriers excluded the water from a pit excavated 150 ft. below the old river bed and drained by a battery of seven steam pumps which raised the water from the deepest part in two lifts and sometimes handled as much as 10,000,000 gallons in twenty-four hours. Earth was excavated by hand and by steam shovels and was removed to the adjacent spoil banks by teams, by locomotives, by an inclined plane and hoisting engine serving depths of over 70 ft., and finally by three cableways about 2,000 ft. long parallel with the axis of the dam and nearly 300 ft. above the lowest excavation. The gneiss and limestone rock underlying the earth had a very irregular surface, and much of it was so unsound that it had to be excavated to a considerable depth. Very interesting work was done in filling the fissures and seams with concrete and cement, and in handling the strong springs which rose through them to a considerable height. The masonry was laid by the aid of the cableways and about 30 large stiff-leg steam derricks, which were carried up on the top of the masonry as it progressed.

Rating Petro Engines by Cylinder Dimensions.—Mr. Dugald Clerk, M. Inst. C.E., in an interesting paper read before the Automobile Club* on this subject, definitely stated that it was impossible to devise a rating rule which would enable one to accurately estimate the power of any engine for cylinder dimensions only.

To obtain any such accurate rule would require uniformity of mean pressures, cylinder proportions, piston speeds, and engine revolutions, which would tend, in the author's view, to impede progress, rather than assist it.

Before a rule can be framed at all, it is necessary to get accurate information as to the mean pressures produced, the piston speeds used, the total cylinder volumes used, and even the number of revolutions. If we could have standard mean pressures, standard cylinder proportions and piston speeds, then, no doubt, accuracy would be possible; but the accuracy of this year would assuredly be inaccuracy five years hence, and positive error in ten years.

In order to consider the matter, Mr. Clerk had certain tests made, from which Table I. has been prepared.

The mean pressure is arranged under two columns. In the one case the mean pressure given is the exact equivalent of the brake horse-power, without allowance for friction; that is, it is that proportion of the mean pressure upon the piston which is really delivered from the engine in brake-horse power. The second mean mean pressure column gives the mean pressure upon the piston, assuming the mechanical efficiency of each engine to be ·8.

It will be observed that the mean pressure equivalent to brake horse-power varies from 61 as the minimum to 81 as the maximum. The highest mean pressure actually exerted on the piston is 101·5 lb. per sq. inch, and the lowest 76·4. With pressures varying so much as this, it is obvious that no rule could be given depending on cylinder dimensions only, which would estimate, even with approximate accuracy, the power to be given by two engines.

* *Automobile Club Journal*, March 29th.

PETROL MOTOR TESTS.

Engine.	Cylinders. Diameter.	Cylinders. Stroke.	B.H.P.	Revolutions per minute.	Mean pressure equal to B.H.P.	Mean pressure on piston M.E. ·80.	Piston speed, ft. per minute.
	inches.	inches.			lb. per sq. in.	lb. per sq. in.	
6 h.-p. Wolseley	1 of 4·5	5	6·5 at	950	68·2	85·2	791·6
Dr. Watson's	2 ,, 3·5	4	3·7 ,,	590	64·3	80·4	393·2
			4·4 ,,	700			466·8
12 h.-p. Siddeley	2 ,, 4·5	4·5	12 ,,	1000	66·4	82·8	750
15 h.-p. Siddeley	4 ,, 4	4	19·2 ,,	1200	63·0	78·8	800
25 h.-p. Siddeley	4 ,, 4·5	5	35 ,,	1200	72·6	90·7	1000
			31 ,,	1200	64·2	80·2	1000
28-36 h.-p. Daimler ..	4 ,, 4·32	5·9	35·6 ,,	1000	83·0	103·8	983·2
			32·0 ,,	1000	74·6	93·2	983·3
32 h.-p. Siddeley	4 ,, 5·25	5	45 ,,	1200	68·5	85·6	1000
28 h.-p. Humber	4 ,, 4·5	5·75	28·5 ,,	900	68·6	85·7	862·5
Siddeley Racer, 1904 ..	4 ,, 7·125	6	85 ,,	1150	61·1	76·4	1150
Vertical Gas Engine, National Gas Engine Co., Ltd.	3 ,, 9	12	75 ,,	450	57·6	M.E. ·85 67·8 lbs. per sq. in.	900

Two engines of exactly the same cylinder dimensions with this variation in mean pressure, would vary as much as 25 per cent. in rated power. Judging, however, from these numbers, it appears to the author that it would be very near the truth to say that a petrol engine of first-class construction should give a brake equivalent about 70 lbs. per sq. inch mean pressure upon the piston.

From these tests Mr. Clerk suggested that for all petrol engines power might be calculated on the assumption of a brake equivalent of 70 lb. per sq. inch on the area of the cylinder, and for engines up to 12 h.-p. piston speed 800 ft. per minute, and over 12 h.-p. 1,000 ft. piston speed per minute. A rule based on these assumptions would be of the form $\frac{D^2 \times N}{C}$, where D is the diameter, N is number of cylinders, and C is a constant. The constant will be different for engines up to 12 h.-p, and engines above 12 h.-p.

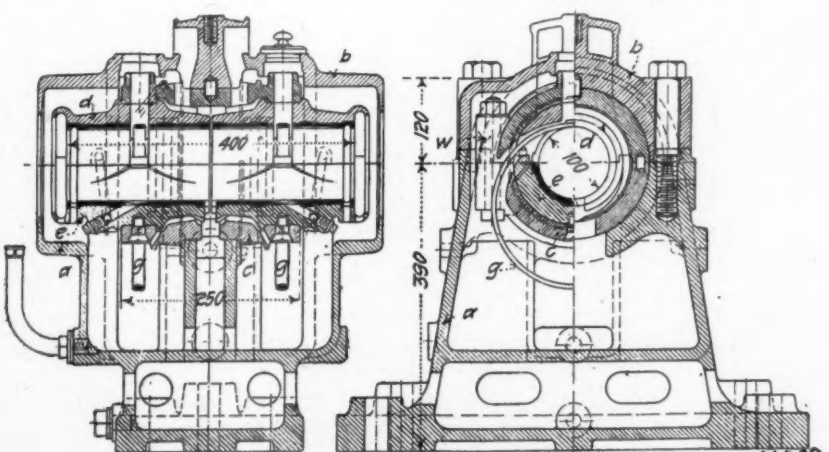
Such a formula was not really what one could call scientific, because it took no note of the fact that higher piston speeds could be attained with longer than with short strokes. Altogether, it seemed hopeless to expect to get any really accurate formula in our present state of knowledge. It was quite possible, however, to obtain more accurate information than we had at present. It will be noted, in looking at Table I., that mean pressures vary much, but that 70 lb. per sq. inch on the piston, as brake equivalent is not far out from the ordinary result. Taking 70 lb. per sq. inch and 800 ft. for piston speed, the formula for power would be $\frac{D^2 \times N}{3}$ and with 70 lb. per sq. inch and 1,000 ft. piston speed, $\frac{D^2 \times N}{2{\cdot}4}$.

A Subdivided Self-Aligning Bearing for High-Speed Work.—A shaft-bearing of interesting design is shown in the accompanying sectional drawings.* It is intended for high-speed work, where journals of great length and small diameter are required in order to provide sufficient bearing surface without excessive surface speed.

The bearing shown was applied to a steam-turbine alternator unit of 500 KVA. capacity running at 2,000 r. p. m., built by the Alioth Electric Company, of Basle, Switzerland. The journal is, approximately, 4 × 16 ins., and thus has the very high surface speed of 2,200 ft. per minute. The unusual ratio of length can therefore not be reduced, and at the same time a uniform distribution of loading on the journal becomes essential to permit cool running. To promote this latter object the designer has subdivided the bearing into two (longitudinal) halves, independently self-aligning, and connected with an equaliser lever to ensure that each receives an exact half of the total load. By virtue of this construction the bearing is required only to meet the conditions which govern the operation of a 4 × 8-in. bearing, instead of those affecting a bearing 16 ins. long, which are probably four times as severe.

In the drawings the letters *e-e* represent the bearing shells, and *d-d* their caps, lined with babbit. These shells rest in narrow cylindrical seats formed in the sleeve *c*, which is carried at its centre in a ring-shaped seat in the main pedestal casting and cap, *a* and *b*. The sleeve c thus forms an equaliser lever, distributing the load equally between the two bearing shells. The sleeve is split in the horizontal plane, and

* Reproduced in *The Engineering News* from the *Zeitshr. d. Ver. Deutscher Ingenieure.*



SUBDIVIDED SELF-ALIGNING BEARING FOR HIGH-SPEED WORK.

the two parts are held together by four bolts, as shown at the left in the transverse section. Loose-fitting dowels are provided in the several seats to prevent longitudinal displacement of the bearing shells in the sleeve, or of the latter in the pedestal. The bearing is lubricated by two oiling rings (each made in two halves screwed together) and by pressure lubrication supplied through a separate pipe to each shell from an air-chamber reservoir mounted on the side of the bearing (but not shown in the drawings). A baffle-plate *w* at the joint between main cap and pedestal, opposite each oiling ring, prevents the leakage of oil through the joint.

The ring oiling provided in this design is stated to give adequate lubrication for surface speeds up to about 2,000 ft. per minute. With a surface speed of 2,550 ft. per minute, the bearing when using pressure lubrication at 1·5 atmospheres, consumes about one to five gallons of oil per minute. For speeds exceeding 2,800 ft. per minute these bearings are water-cooled by a coil of pipe placed in the oil-pocket of the pedestal.

The Specific Heat of, Heat Flow from, and Other Phenomena of, the Working Fluid in the Cylinder of the Internal Combustion Engine.—At a recent meeting of the Royal Society, Mr. Dugald Clerk read a paper, communicated by the Hon. Charles A. Parsons, on this subject.* The author said he proposed to describe experiments made with a gas-engine of 60 brake-horse-power, designed to obtain data necessary for a more complete theory of the internal combustion motor, and also to discriminate between the effects of continued combustion in a gaseous explosion and specific heat change at temperatures between 200° and 1,500° C. The new method of experiment consisted in alternately compressing and expanding the highly-heated gases within the engine cylinder while cooling proceeded, and observing by the indicator the successive pressure falls and compression and expansion curves from revolution to revolution. From some 200 indicator cards taken under varying conditions, there had been calculated: (1) A curve of apparent specific heat of the gaseous contents at constant volume between 200° and 1,500° C.; (2) curves of heat loss to the enclosing walls; and (3) distribution of heat in the working cycle calculated from diagrams only. The apparent specific heat at constant volume was proved to increase from 22 foot-pounds per cubic foot at 200° C. to 27·4 foot-pounds at 1,500° C.; and an examination of expansion curves and specific heat determinations made at different engine speeds and jacket temperatures showed that combustion was proceeding, and accounted for a part of the apparent increase of specific heat. The curves of heat loss showed that, for equal temperature differences, heat loss per unit surface exposed increased with density. From these curves, the mean temperature of the cylinder walls had been calculated, and shown to vary at full load from 190° C. for the whole stroke to 400° C. for the three-tenths stroke. Calculations made of heat distribution in the working cycle of the fluid, showed that the total heat present in the form of combustible gas could be accurately calculated from the indicator diagram alone by means of the new data obtained in the investigation.

Handling Coal and Goods on the Chicago Subway.—In connection with the Chicago subway a single-track tunnel has now been completed along the centre line of practically every street in the business district of the city. These tunnels are all approximately 42 ft. below the street level, and are connected in various ways with buildings in streets under which they pass. Of the freight traffic that will be carried on in the subway, one of the most important sections will be the delivery of coal to the buildings from the coal depôts of the various railways. Three general types of connections have been made for this traffic, two of which are applicable for handling other materials. An example of one of these connections is shown in Fig. 1,* which illustrates a coal elevating and conveying plant installed in the first National Bank building. This plant is designed to handle coal from a connection with the subway to a storage room in front of a row of boilers in the basement of the building. A steel-lined hopper is placed under the track in the tunnel connection, and coal is dumped from the tunnel cars into this hopper. An automatic reciprocating feeder, built in the bottom of the hopper, supplies the coal to a gravity discharge elevator-conveyor built in a shaft, which extends up to the basement floor level of this building, at the side of the tunnel connection. The elevator-conveyor is erected vertically in the shaft reaching to the ceiling of the basement and then extends horizontally across the coal storage room. The buckets on it are arranged so that they replace the usual flight conveyor, and with a specially designed automatic device, the coal can be dumped from them at any point in the horizontal portion of the conveyor.

Where the coal consumption is too small to justify the outlay necessary to instal such system of conveyors, another type of connection is adopted.

A by-pass to the tunnel extends under the front of the building and is connected to the basement of the building by an elevator shaft. Loaded tunnel cars are raised to the basement floor level by an elevator large enough to handle one of the tunnel cars which is installed in the shaft.

A gravity coal-handling plant for this traffic has been installed at the coal depôt of the Chicago and Alton Railway, the features of

* Abstract *Times Engineering Supplement.*

* *The Engineering Record*, vol. 53, No. 13.

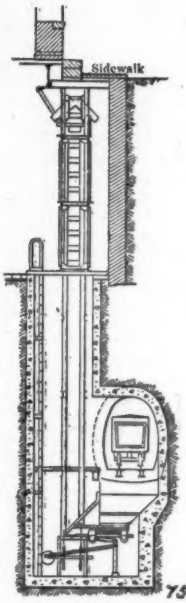


FIG. 1.

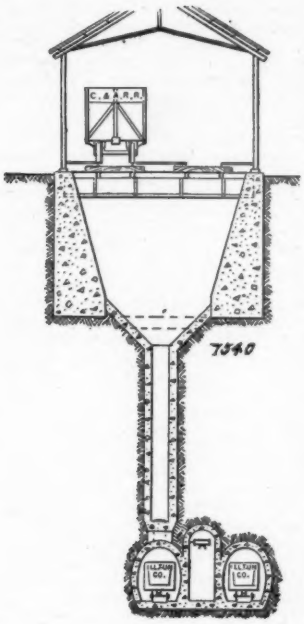


FIG. 2.

COAL HANDLING ON THE CHICAGO SUBWAY.

which will be gathered from Fig. 2. It consists of three large rectangular concrete-lined hoppers, across which two of the yard tracks are carried longitudinally on transverse steel girders. Leading from the centre of the bottom of each concave section is a vertical chute, which extends down to two short inclined chutes built through the arch of a connection with the tunnel system 480 feet below the ground level.

The side and end walls of the hoppers have heavy monolithic concrete sections, and the partition walls are of reinforced concrete. The circular bottoms and the chutes leading from them to the tunnel are lined with concrete, the latter being cased on the inside with steel plates to avoid abrasion. The lower end of each of the two inclined chutes, is fitted with a valve that controls the opening.

Standard gauge dump cars are run over the hoppers, and the coal dumped from them by gravity. Trains of 3 to 8 cars handled by an electric locomotive are used in the coal traffic. These cars, which are of steel, have two four-wheeled trucks of 28-in. gauge, and have a capacity of about 6 tons. The cars are arranged to dump from both sides. All of the cars of a 6-car train can be loaded at the same time, an operation which, under normal conditions, can be readily done in two minutes.

The Transfer of Heat at High Temperatures.*—The experiments referred to in this paper were made to determine the time required to raise plates of iron and steel to a welding temperature in an open hearth regenerative furnace. Some preliminary experiments were made by heating plates in a muffle of the size commonly used in chemical laboratories. Four different samples of metal were experimented upon. These samples were cut from stock plates used in the manufacture of butt-weld pipe. The dimensions of the samples were as follows:—

No. of Plate.	Material.	Length.	Width.	Thickness.
		inches.	inches.	inch.
1	Iron.	6	1·25	·104
2	Iron.	6	1·25	·117
3	Steel.	6	1·25	·111
4	Iron.	6	1·25	·129

The temperature of the specimen plate was measured by a Le Chatelier thermocouple, a second thermocouple being located in the furnace adjacent to the plate for the purpose of measuring the furnace temperatures.

* *Trans. American Society of Mechanical Engineers*, vol. xxvi.

The results obtained show with Stefan's law of the radiation of heat a very satisfactory agreement. According to Stefan the heat absorbed or radiated is proportional to the difference of the fourth powers of the absolute temperatures. Expressed algebraically, $Q = \sigma (\tau_1^4 - \tau_2^4)$, where τ_1 is the absolute temperature of the furnace and τ_2 is the absolute temperature of the plate being heated.

The average value of $\sigma \times 10^{15}$ was for plate 1, 2·23; for plate 2, 2·15; for plate 3, 1·72; for plate 4 in muffle, 2·27. Plates 1, 2 and 4 were of wrought iron, while plate 3 was of steel. The average then for all the tests made upon wrought iron plates in the muffle was 2·22. It appears that the coefficient of emissivity for steel is less than for wrought iron by about 20 per cent.

One striking result of these tests is brought out by comparing the times required to bring the plate up to the temperature of the furnace. In the muffle tests about three minutes were required, while in the open hearth tests one minute sufficed to heat the plate substantially to the furnace temperature. If the law of Stefan holds for the radiation and absorption of heat under practical working conditions, as seems to be the fact, then some very significant relationships exist in the transfer of heat to the heating surface of a steam boiler. Compare two cases where the furnace temperatures are 2,000° and 2,500° Fahr. respectively, and a portion of the heating surface is exposed to direct radiation from the fire. The heats transferred by radiation will be as 37 to 77 in the two cases. In other words, adding 500° to the temperature more than doubles the radiant heat transmitted to the water in the boiler.

On the Resistance of Iron and Steel to Reversals of Direct Stress.—While recognising the valuable work which has been done by previous observers in the study of the fatigue of metals, further experimental work on the subject is much needed for the following reasons:—(1.) Practically all the previous work, with the exception of Reynolds' and Smith's experiments, has been done by subjecting the materials to transverse stresses, the intensity of which has, therefore, to be calculated by the ordinary theory of bending. (2.) The resistance of the materials in common use by engineers at the present day when subject to reversals of stress is imperfectly known, and there exists considerable difference of opinion as to the materials best suited for stresses of this kind. (3.) Although it appears from Reynolds' and Smith's experiments that the resistance of iron and steel is seriously diminished when the alternations are very rapid (*i.e.*, 1,500 to 2,000 per minute), it is not known if this reduction in resistance is considerable at those speeds which are common in high-speed reciprocating motors (*i.e.*, in the neighbourhood of 800 reversals per minute), since the majority of experiments have been made at approximately 60 reversals per minute. (4.) Although it is generally recognised that the effect of moderately rapid or sudden changes in section of materials subject to reversals of stress is to diminish their resistance, the amount of this reduction in strength for the various materials commonly used is not known. (5.) The common assumption that, in cases in which the stress varies from tension to compression, but between unequal limits, the resistance depends solely on the range of stress and not on the actual values of these limits, has not been experimentally verified.

From these considerations Dr. Stanton, M.Inst.C.E., and Mr. L. Bairstow, A.R.C.S., decided to undertake a research,* the object of which should be the experimental determination of the resistance of certain kinds of iron and steel, under the special conditions mentioned in the above paragraph, when subject to reversals of direct stress.

The experiments were made on the alternating stress testing machine which has been designed and constructed at the National Physical Laboratory, and which has been fully described in THE ENGINEERING REVIEW.*

Jointly with this work, a microscopical investigation has been made of the changes which take place in the crystalline structure of materials under reversals of stress as the test proceeds, to determine if possible the manner in which ultimate failure occurs.

The materials upon which the tests have been made may be conveniently divided into three groups:—(1.) Three samples of Swedish Bessemer steel and one sample of Swedish charcoal iron presented by Mr. R. A. Hadfield for the purpose. The carbon content of the steels was approximately 0·17, 0·44 and 0·64 per cent. (2.) Four samples of steel presented by Messrs. Belliss and Morcom for the purpose. Of these, two were mild-steel bars, one was a bar of harder steel used for piston-rods, and the fourth consisted of specimens which had been cut from a large steel forging. (3.) Two samples of wrought iron of British manufacture, bought for the purpose of the tests.

Although more uniformity in the result of the tests would no doubt have been obtained by subjecting all the specimens cut from any given material to an annealing process, it was felt that this would detract from the value of the tests owing to the well-known effect of heat treatment on the resistance of steel. For this reason the tests were made on the bars as received; and in cases in which there were several bars of the same material, the specimens in any group of tests were not always cut from the same bar. This does not apply to the case of the specimens whose structure was examined microscopically, in which the actual resistance was of secondary importance.

The results of the experiments may be stated briefly as follows:—1. The superiority, in resistance to reversals of stress, of moderately high-carbon steels over low-carbon

* *Proc. Inst. Civil Engineering*, April 10th, 1906.

steels and wrought irons, which was discovered by Wöhler to exist when the rate of reversals was sixty per minute, still holds when this rate is increased to 800 per minute, although according to Reynolds and Smith's experiments this superiority no longer exists when the rate of reversals is in the neighbourhood of 2,000 per minute. 2. As far as comparisons can be made between the results of the present experiments and those of Wöhler and Sir Benjamin Baker, there is no marked reduction in resistance due to raising the rate of reversals to 800 per minute. 3. Experiments in which the ratio of tension to compression varied from 1·4 to 0·72 indicated that between these limits the value of the maximum range of stress was practically independent of the actual values of the limiting stresses in tension and compression. 4. The resistance of the materials in three typical cases of rapid reduction of area of the specimens has been determined. 5. The failure of iron specimens due to the development of the slip-lines of Ewing and Rosenhain into cracks has been determined for the case of direct stress; and the failure of moderately high-carbon steel, due to the development of cracks in the ferritic areas of the structure has also been established.

Forging Presses.*—A few years ago forging presses were looked upon generally as suitable only for quite the heavier classes of work, presses of 2,000 tons power and upwards being generally used. The useful speed of working presses of this size was, to a great extent, limited by the speed with which the forging could be manipulated, ranging generally from ten up to twenty-five strokes per minute. Various improvements have enabled the working speed of presses to be increased up to sixty and even eighty strokes a minute, and with such speeds as these presses can compete with hammers for even quite light work, and consequently the range of the applications for which presses are suitable is greatly extended.

By far the strongest form of press is the duplex cylinder press, with central guide cylinder fixed on the entablature. The two-cylinder press is considerably more expensive than the single cylinder, but for the larger powers, say, from 2,000 tons upwards, the advantages gained are well worth the additional cost. For presses of smaller powers, say from 300 up to 1,500 tons, a single cylinder press can be constructed which is in every way satisfactory.

As to the methods of driving the press, the system which has been most generally used in the past is by means of pumping engines. The simplest arrangement is to have a set of pumping engines running constantly. The lifting of the press head is effected by constant accumulator pressure, the lifting cylinders being of sufficient power both to lift the weight of the press head and to discharge the water from the main cylinder into an overhead tank, or an air vessel. With this system a speed of as much as thirty strokes per minute can be obtained with presses of 2,000 to 3,000 tons power, but the pumping engines have to be large, and the consumption of steam is considerable.

The system of working forging presses by means of steam hydraulic intensifiers has recently come into more general use owing to improvements that have been made under the "Holmes and Davy" patents.

With regard to the work to be done under the press, for mild steel at a fair heat a pressure of from three to five tons per square inch on the face of the tools is generally sufficient, but when swages or dies are used, quite double these pressures are requisite. For the very hardest high-speed steels the pressure required may increase up to ten to fifteen tons per square inch. For engineers' small forgings, including such work as can be made out of 8-in. square blooms or 12 in. by 6 in. flats, a press of 300 tons is sufficient, and for the largest forgings that are usually required for the heaviest marine shafts and cranks a 3,000 ton press is generally considered sufficient, and can deal very well with a 60 in. ingot.

For the heavier forgings far better work can be done under the press, and much more reliable forgings produced than by any hammer, as it is not practically possible to have a hammer of sufficient weight to get to the centre of a large ingot, the surface metal being spread whilst the centre of the ingot is not affected. With a press the action goes right to the centre of the ingot. If there is any cavity in the ingot, forging under the press tends to close it, whereas a hammer by spreading the surface metal tends to enlarge it. There can be very little doubt that pressed forgings are the soundest and most reliable. Small presses are only now beginning to come into general use. A press of good design and workmanship uses only about one-half the steam required by a hammer in good working order, and is far less liable to become wasteful, as hammers invariably do through the wear of the working parts. In cost of repairs the press has a great advantage, the wear and breakage of working parts being very small compared with what it is with hammers.

Less skilled labour is required for working a press than a hammer, and, taking everything into consideration, the much smaller consumption of steam, smaller cost of upkeep and repairs, and the much larger amount that can be done at a heat, the cost of work done under both large and medium-sized presses is undoubtedly very much less than with hammers. In small work as done in a general engineering works, the total cost for a press works out at 21*s*. 11*d*. per cwt., and for the hammer at 26*s*. 4*d*. Labour with the press may be put down at 6*s*., with the hammer at 8*s*. 5*d*.; incidentals at 6*s*. 0½*d*. with the press, and 7*s*. 10*d*. with the hammer; cost of materials being 10*s*. per cwt. in each case.

* Paper by Mr. A. J. Capron, M.I.Mech.E., Cleveland Institution of Engineers.

BOOK REVIEWS.

The Law and Practice Relating to Patents, Trade Marks, and Designs. By DAVID FULTON, Assoc.M. Inst.C.E., of the Middle Temple and Northern Circuit, Barrister-at-Law. Third edition. 1905. (London: Jordan & Sons, Ltd.). 12s. 6d. net.

It is not necessary to emphasise to readers of this magazine the important part played in the commercial and industrial life of the community by letters patent and registered trade marks and designs. Everyone who has considered the subject at all knows that the fierce competition in trade at the present day causes manufacturers and traders to be constantly on the alert for new inventions which may be protected, and for other means of distinguishing their goods from those of their rivals. In this state of affairs it is necessary that they should have at their disposal a trustworthy guide to the law relating to patents, trade marks, and designs, as there are many pitfalls where the unwary may come to grief. Mr. Fulton's volume, now before us, appears to us to provide what is wanted. The book has been before the public for some time now, so that a detailed description is not necessary, but the appearance of a new edition—the third—calls for notice, inasmuch as it deals with the changes in the patent laws which have recently come into force. The Patents Act, 1902, altered very materially the procedure to be followed at the Patent Office in dealing with applications for letters patent, and the new procedure came into force at the beginning of last year. There is now instituted a qualified search for anticipations of inventions forming the subject of applications for protection, and inventors will save themselves much trouble and possible annoyance by careful attention to the provisions of the new Act and to the new Patent Office Rules. The publication of this new edition of Mr. Fulton's work has been delayed in order that the author might be able to give information on the practical working of the new system, and practitioners as well as the general public will be interested by his remarks on this subject. For ourselves, we are especially pleased to learn that the new power of the Comptroller with regard to the insertion in specifications of specific references to earlier patents, is being used cautiously, and that "so far as present practice is a guide, it is evident that references are not to be indiscriminately made."

It is unfortunate that this edition should have been prepared just too early to deal with the new Trade Marks Act which was passed in the recent session of Parliament, but no doubt a future edition will deal extensively with the new law on this branch of the subject.

A very useful feature of the volume is the presentation of all the Patents Acts from 1883 to 1902 consolidated and codified. Every practitioner knows the inconvenience of having to hunt up a number of separate statutes in order to find the exact state of the law, but here he will find the principal Act set out with the sections of later amending Acts interpolated in different type at the proper places, while the same procedure has been followed in dealing with the Rules. Useful as the volume will undoubtedly be to the patentee who wishes to be his own agent or lawyer, it will be appreciated still more by the patent lawyer. The discussion on legal points, though brief, is always clear, and the extensive references to cases put the reader at once on the proper track for further investigation. There is a separate extensive index for each part of the volume—that is, one for patents, one for trade-marks, and one for designs, and the three together take up 124 pages of the volume out of a total of 672. In appendices there are given useful precedents for such matters as the sale of patent rights, assignments, grant of licences, &c. The preparation of the volume must have entailed much labour on the author, but he will no doubt be repaid by the appreciation it will receive from the public. The book has a handsome appearance and is excellently printed.

The Inventors' Guide to Patent Law and the New Practice. By JAMES ROBERTS, M.A., LL.B., of the Inner Temple, Barrister-at-Law; Author of "The Grant and Validity of British Patents for Inventions," 1905. (London: John Murray. Price, 2s. 6d. net).

In spite of the very strict technical provisions of the patent laws of this country, there is a host of inventors who rush to the Patent Office to register their new inventions without taking proper pains to understand what the law requires of them. If things go wrong afterwards, the blame is put upon the authorities or upon Parliament, and letters are written to the press condemning our patent system. But in fact a little more care on their part at the outset would have prevented trouble, and nowadays it is not difficult for any would-be inventors to obtain ample information on the requirements of the law at a very small cost. There are many books available to him, and one more has recently been added to the number in the volume now before us. The year 1905 brought with it the inauguration at the Patent Office of the procedure authorised by the Patents Act, 1902, and Mr. Roberts, who had previously published a large and comprehensive work dealing with the patent laws, old and new, has thought it worth while to follow up the more

technical treatise with a small practical handbook, giving inventors a simple outline of the law as it now stands, and informing them of "the proper manner of protecting their inventions so as to avoid the risk and consequence of premature disclosure of their ideas." In a series of short chapters he explains the origin and development of our present laws, and the leading features of their provisions. What is patentable, and what is not; who may obtain patents, and who may oppose the grant; what the inventor must attend to in drafting his specification, and what the conduct of the Patent Office regarding it will be—these are all questions considered briefly by Mr. Roberts, who has endeavoured to put much useful information into small compass. An appendix contains the Act of 1902 and the new rules.

Le Four Electrique, Son Origine, ses Transformations et ses Applications. Par ADOLPHE MINET, Fondateur de l'usine d'aluminium de Saint-Michel de Maurienne, Directeur du journal *L'Electrochimie*. Premier fascicule, 1905. (Paris: Librarie Scientifique A. Hermann. Price, 4s.).

If we consider the progress that has been made during the past twenty years in all the different fields in which electricity has been applied, we shall find nowhere more striking results than have been obtained in electro-metallurgy and electro-chemistry. The general public does not see or know much of this department of electrical science, but when it is realised that whereas the electro-metallurgical industries practically were non-existent twenty years ago, they to-day use over half-a-million horse-power in carrying on their work, an idea may be obtained at once of the importance of these industries and of the rapidity of recent progress. For this development the electric furnace is responsible, and it is not surprising therefore that various writers should have been led very recently to devote special treatises to the discussion of this apparatus. The volume now before us is the first instalment of a work which promises to be perhaps the most complete practical work on the subject. The author proposes to publish in all five volumes, which together will give a comprehensive discussion of the electric furnace from the historical, the scientific, and the industrial points of view. As regards the historical treatment, the author divides the time from the invention of the electric furnace up to the present date into three periods—the first (1808–1886) deals with the apparatus as a laboratory appliance: the second (1886–1890) shows the development of the furnace for use in practical industries; while the third deals with the advances made in its application from 1890 down to the present time. Each volume will contain two parts, one historical and descriptive, the other devoted to the theories of electro-chemistry and physical chemistry and giving such information as will enable the reader to follow the general discussion without having recourse to special text books. Each volume is to contain also a bibliographical index for the period with which it deals, and the final volume promises to be of great value as a work of reference, as it is to be devoted to statistics and will contain a list of the patents concerning the electric furnace, granted in France and other countries up to the year 1906.

The present volume deals with the first historical period—that is, from 1808, when Sir Humphrey Davy undertook his work on the electrolysis of the alkaline earths, up to 1886, when the advance was made from the laboratory furnace, working only for a short time, to the industrial furnace capable of production on a commercial scale. The descriptive portion of the volume deals first with the origin of three distinct types of furnace—the voltaic arc of Davy, first produced in 1813; the resistance furnace of Pepys (1815): and the cathode furnace of Davy (1808-1810)—and then discusses the development of different forms of apparatus for electrolysis by igneous fusion. The author deals here in succession with the electro-metallurgy of aluminium, magnesium, lithium, sodium and potassium, and the alkaline earths, and finally gives particular descriptions, accompanied in many cases by illustrations of furnaces of different classes covering the period from 1849 to 1886. A historical discussion of this kind, if it were merely a chronological index of the different forms of apparatus produced during the period under consideration, might be of little real value to the student; but Mr. Minet makes his work at once interesting and valuable by showing at each stage what were the novelties presented by particular types of apparatus and the progress made by the introduction of these new ideas, and again indicating the difficulties, failure to overcome which prevented the great step of progress from the laboratory furnace to the industrial furnace.

The theoretical portion of this volume is both simple and clear. It is mainly concerned with the development of the fundamental laws of electro-chemistry, and we have been especially struck by the clear method of the exposition of the nature of electrical conduction in electrolytes and its dependence upon the state of dissociation of the dissolved substance.

This volume contains eight full-page portraits of men whose names are prominently connected with the development of electro-metallurgy. We wish that room could have been found in this gallery for one of Sir Humphrey Davy, the earliest worker on the subject. The page of the volume is of large size and broad, and although the type is clear, the lines—no doubt for economy of space in so extensive a work—are printed very close together. This is, we think, unfortunate, as we have found it a strain on the eyes to follow the text from one line to the next. On p. 46, second line below Table III., there is a misprint, "ou cuivre" for "au cuivre."

List of Journals the principal contents of which are regularly indexed. The papers dealt with are those received between the 10th of the month preceding that of publication and the 10th of the previous month.

American Engineer and Railroad Journal, 140, *Nassau Street, New York* ... ... 20 cts.
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Dingler's Polytechnic Journal, *Berlin* .. ... { 3 mos. / 6 mrks.

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Electrical Review, N.Y., 41, *Park Row, New York, U.S.A.* ... ... 10 cts.
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Der Electro Techniker, *Hengasse, 62, Vienna*... 60 pfs.
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NEW CATALOGUES.

W. H. Bailey & Co., Ltd., Salford, Manchester, List No. 406, of patent "Key Ring" steam stop valves. The special feature of this valve is the removable valve seat which is screwed into a cast iron split ring, the latter being sprung into a recess in the valve body. As the split ring is loose and free to expand, no warping or twisting of the face can occur.

Ernest Scott and Mountain, Ltd., Newcastle-on-Tyne. Handsome catalogue of high-speed engines and direct-coupled generators. These engines, we understand, are giving exceptionally good results, and are in use at such works as the Consett Iron Co., Ltd., R. Stephenson & Co., Ltd., Kent Collieries, Ltd., Cammell, Laird & Co., Ltd., &c.

The Simms Manufacturing Co., Ltd., Kilburn. 1906 edition of their catalogue of commercial vehicles. These include omnibuses, vans and lorries, powered from 12-14 up to 28-35 h.-p.

Bradbury & Co., Ltd., Oldham. Catalogue of machine tools. The "Reliance" turret lathe has some interesting features. In addition to the regular turret carriage it has a carriage fitted with a cross slide, the latter having a turrret tool holder to carry four tools. This carriage is of a new design, admitting of its being run directly under the chuck up against the head, allowing the main turret to be operated close to the work, doing away with the necessity for long box tools and boring bars, with their consequent overhang and lack of rigidity. The tools in the turret tool post can be instantly fixed in any position, obviating the use of bent tools for working in the corners of a flange, etc. Further, the tools on the cross slide can be used to work on pieces of a large diameter, as the lathe will swing over the carriage ways. The turret of this machine is also of novel design, and instead of being the usual circular or hexagon shape, has three long and three short faces. Another machine of recent design is the 8-inch friction, back-geared lathe, possessing various special features. One of these is a new automatic screw feed, which is instantly engaged by movement of lever, feeding any length desired within the capacity of the machine.

Chain-Belt Engineering Co., Derby. Catalogue No. 15 of apparatus applied to the economical handling of raw materials and manufactures; also to the transmission of power.

C. W. Hunt Co., New York. List OC_3 of coal handling machinery.

Alfred Herbert, Ltd., Coventry. List Q. Shaping and slotting machines.

Simplex Steel Conduit Co., Ltd., Birmingham. List of recent additions to this firm's specialities for interior electric wiring.

TRADE NOTES.

The Paterson Engineering Co., Ltd., Norfolk St., Strand, W.C., advise us that amongst other orders lately received for Paterson Purifiers for Power Plant are the following: Water Softener and Heater with quartz and filter of 6,000 gallons hourly capacity for the Fife Coal Co., Cowdenbeath Pits; two Exhaust Heaters and Softeners, each of 33,000 lbs. hourly capacity, for the Derbyshire and Nottinghamshire Electric Power Generating Station; one Condensation Water Purifier of 3,000 gallons hourly capacity for the Electricity Works, Heckmondwike; one Condensation Water Purifier and Grease Eliminator with make-up Softener of 2,500 gallons hourly capacity for the London and North-Western Railway Company's Crewe Works; one Water Softener and Heater with quartz and filter of 6,000 gallons hourly capacity for the Balgonie Colliery Co., Thornton Junction; two Condensation Water Purifiers and Grease Eliminators for the London County Council; Water Softener and Heater with quartz and filter of 2,000 gallons hourly capacity for the Tranmere Bay Development Co., Birkenhead.

Engineering Standards Committee. The Secretary of State for India in Council has nominated Mr. A. Brereton, C.S.I., to represent the India Office on the Sectional Committee on Locomotives (Chairman, Sir Douglas Fox) in the place of Sir Frederick R. Upcott, Chairman of the Indian Railway Board. The Council of the Institution of Naval Architects have nominated Mr. Sidney W. Barnaby, of Messrs. John I. Thornycroft and Co., to represent that Institution on the Sectional Committee on Screw Threads and Limit Gauges (Chairman, Mr. H. F. Donaldson, Chief Superintendent of the Ordnance Factories) in the place of Mr. McFarlane Gray, resigned.

Ed. L. van Nierop & Co., Yokohama, have recently added an Engineering Department to their business and are prepared to receive catalogues and appointments for representing British makers in the Far East.

Messrs. John I. Thornycroft & Co., Ltd., Chiswick, advise us that the paddle steamer "Princess Royal," built at their Southampton Works for the Southampton, Isle of Wight, and South of England Royal Mail Steam Packet Co., Ltd., was successfully launched on April 10th.

The Pulsometer Engineering Co., Ltd., Reading, have on order, in addition to many other plants for various trades, the following: "Criton" Water Softeners for Gas Works, namely, a 3,000 gallons per hour plant for the South Metropolitan Gas Co., East Greenwich, and a similar-sized plant for the Ipswich Gas Co.